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AND ABSTRACT OF THE LITERATURE

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(Continued)

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THE PHYSIOLOGY OF INDUSTRIAL HYGIENE: I. THE RELATION OF INDUSTRIAL FATIGUE TO GASTRIC AILMENTS*

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IT HAS long been recognized that persons under severe physical and mental stress may suffer from what is popularly called "indigestion," but it does not appear to be appreciated that even minor degrees of stress, such as may occur in industry, have a very definite causal relation to gastric ailments quite apart from dietetic considerations. Such ailments, it becomes evident, have a special significance in industrial fatigue.

Only of recent years has this relationship become apparent and it is necessary in the first instance to outline the main principles involved. Generally, in all states involving physical or mental stress the activity of the alimentary canal is reduced, and when we consider the control of the alimentary canal the physiologic basis of this fact becomes evident.

The canal is controlled from the central nervous system through what has been termed the autonomic nervous system, one of whose main functions apparently is to co-ordinate the internal mechanisms of the body for purposes of physical activity. Generally, it may be understood that the essential part of this co-ordination is the shutting down of all activities, *e.g.*, alimentary, not immediately essential to the animal for the purpose of supplying more oxygen and nutriment carrying blood to the more active tissues such as the muscles. The part of the autonomic nervous system concerned with such co-ordination is the sympathetic; while the other main division of the system, the parasympathetic, has to do chiefly, so far as the

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alimentary canal is concerned, with augmenting the activity of the latter during rest, *i.e.*, with the general propellant action of the musculature and the secretion of the digestive juices. The shutting down of the alimentary activity, on the other hand, consists in the inhibition of such secretion and propellant action, together with the contraction of the pyloric and ileocolic sphincters which prevent the passage of food from one part of the canal to another.

The evidence on which this general view is based is now very definite and consists of: experiments in which nerves have been stimulated; inferences drawn from the use of drugs; and, still more, direct observations in man by means of X-rays and examinations of gastric contents. For example, it can readily be demonstrated that a profuse secretion of saliva may be brought about by stimulation of the chorda tympani, *i.e.*, part of the parasympathetic supplying the submaxillary gland, or by the injection of pilocarpine which stimulates the parasympathetic nerve endings. Similarly there is a secretion of gastric juice or of pancreatic juice when the vagus is stimulated. In relation to the movements of the canal, the nature of the augmentation of the contraction appears to depend on the state of the organ, which contracts when it is full, and dilates when it is empty (1). In relation to the sphincters, the most definite evidence is that put forward by Smith (2) and by Elliott (3) who showed that the pyloric and ileocolic sphincters are caused to contract by adrenaline, a drug which acts like the sympathetic nervous system. It is important to observe that this drug, which is elaborated by the suprarenal gland and is considered to be poured out in conditions of stress, also causes inhibition of intestinal movement.

With the basal facts before us and the knowledge that in physical and mental stress there is increased sympathetic and reduced parasympathetic activity, as shown by the increased heart rate, the constriction of the unused blood vessels, and the like, we begin to see how the alimentary canal may be profoundly affected under such conditions.

It has long been known that if a dog is fed and hunted immediately afterwards the food does not leave the stomach, and it is common knowledge that no football player would attempt to play a game on a full stomach as he would rapidly realize that the load in the stomach had become immobile. Similarly it is recognized that in stress the usual pangs of hunger are absent, which pains we know are merely those associated with certain gastric movements. Recent work, especially that of Hurst (4), has made it clear that pain in the region of the pylorus is due either to excessive contraction of the pylorus itself or to failure of the sphincter to open and the attempt of the pyloric end of the stomach to drive its contents through the inadequately opened exit. Such inadequate opening of the pylorus is the result of sympathetic stimulation and brings about indirectly the pain which any normal person may experience if he indulges in a large meal when excessively fatigued.

This insufficient opening of the py-

lorus has also been shown to be important not only in the emptying of the stomach but also later when the stomach is empty. At this time there occurs normally a regurgitation through the pylorus to prevent excessive acidity in the stomach (5). If this regurgitation does not take place, a condition of hyperchlorhydria arises in which there is special liability for gastric ulcer to occur, should the mucous membrane become injured.

The influence of mental stress may also be evident in the inhibition of secretion; indeed, this was the basis of one form of trial by ordeal in which an accused person was deemed to be guilty if he was unable to swallow a quantity of dry flour. The presence of a supply of water on a lecturer's table has a similar significance since it can readily be appreciated that the thirst is more dependent on the mental stress of the occasion than on the fact of talking, which does not affect the secretions of the mouth under pleasant circumstances. That this secretion of saliva is of first importance in the digestion of starch has become more and more evident since it became recognized that salivary digestion may go on for a very appreciable time in the stomach and that its products may influence gastric and, indirectly, pancreatic secretion. Direct evidence has also been obtained of an inhibition of gastric juice during emotion (6).

These facts are the basis of a new nondietetic consideration of gastric hygiene. Contrariwise, it has been clearly demonstrated that digestion is facilitated by pleasant surroundings during and after meals. We are possibly inclined to think at first sight that only severe conditions of mental or physical stress affect digestion, but the recent work at Guy's Hospital by Campbell and Pembrey (7) shows clearly that quite small variations in surroundings make a difference. Thus a walk may reduce the rate at which the stomach empties, and there is a difference between the effects of a walk taken alone and one in pleasant company. Should there be, in addition, dietetic errors concerned, the general nondietetic conditions if not sufficient in themselves to cause ailment may just turn the scale in an adverse direction, and gastric discomfort results.

It must therefore be emphasized that the periods during which food is taken must be periods of real relaxation and it is most desirable that the taking of food should be preceded and, what is still more important, followed by a rest period. A rest pause in industry concerns therefore not only the muscular and nervous systems but also the alimentary canal. Fatigue physiologically continues the effects of exercise in that it demands blood for the tired tissues as much as did the exercise itself.

Thus it becomes evident that not only may gastric ailments promote inefficiency and stress but such ailments may be looked upon as having a very special significance in industrial fatigue and in general hygiene.

The bearing of the foregoing points upon the value of cheerful industrial canteens to health and efficiency hardly calls for comment.

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THE MEASUREMENT OF THE EFFECTS OF NOISE ON WORKING EFFICIENCY*

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INTRODUCTION

AURAL disorders have been attributed in some instances to exposure to continued noises of high intensity. It has long been recognized that quiet conditions are important for hospital patients, partly because of their apparent effects on the convalescent period, and partly because they remove irritating stimuli from those who have been made especially irascible by physical ailments.

Just what effects the increasing noises of our modern machine civilization have on the workers in the normal course of the day's work has been largely a matter of conjecture. If one were to reason from observations such as those in the foregoing paragraph, the conclusion would be reached that industrial noises not severe enough to cause aural disorders would probably still show an ill effect on the working efficiency of those exposed to the sound stimuli.

The actual effect of noise on output and energy consumption of typists was measured in the Colgate laboratory from September, 1926, until March, 1927. Previous work by John J. B. Morgan, in the laboratories of Columbia University, had indicated that more effort was expended in simple typing under noise distractions than under quiet conditions.

In the Colgate experiments to be described, energy expenditure was measured by the collection and analysis of exhaled air. A gas mask was strapped to the subject's face and connected to adjoining rooms with a system of tubing. From the analyses the total calories expended were computed. The typist worked in a specially prepared test chamber, 15 feet by 6 feet, with a 9-foot ceiling. The room was lighted entirely with semi-indirect artificial light. The walls were of brick, covered with hard plaster.

A "noise machine" was built to reproduce the sounds occurring in the usual busy office. This machine was electrically actuated and was placed on a ledge in one wall of the room. During all the experimental days to be reported the machine was in full blast, making sounds like an electric motor; ball bearings rotated in a hexagonal sheet iron drum; an auto siren and a telephone bell intermittently and automatically. When the walls of the

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[1] Laboratory technicians who assisted in gathering the data upon which this report is based are: Curtis Harford and Thomas Turino in charge; Ivan Sagal, H. P. Lange, James Hunter, Hilda Drexel, Paul W. Allen, and Joseph D. Farranto.

test chamber were uncovered, the full effects of these noises were actually increased through reverberation. In half of the experimental days the sound intensity was reduced through the use of panels of acousti-celotex. From architects' specifications it is probable that these demountable panels reduced the heard sound in the room by about 50 per cent. This has been termed the *quieted phase* of the experiment. During the noisy phase the test chamber was no noisier than many offices.

Experienced typists were experimented upon. Three were of average skill, and one possessed phenomenal skill. The subjects were equally divided between the sexes.

Experimental Procedure

After a uniform breakfast the subjects were transported to the test chamber with a minimum of walking; the masks were attached, sealed with adhesive, and tested for leaks. Each subject then took his place in front of a noiseless typewriter, maintaining the position used when typing, but without actually typing. After half an hour in this position a sample of air was gathered in the Douglas bag. This was the air analyzed to ascertain the *resting energy expenditure*.

As soon as the resting air had been collected, the noise machine was started by closing an electric connection and the typist was instructed to begin work. Electric connections were used to record the time of starting and of finishing each letter, and the time required to take out a completed letter and to insert a new sheet of paper ready to resume writing. The typists worked at maximum speed, without pausing between letters. The same letter was written over and over again, about 2,000 copies being made in the course of the experiments.

Every fifteen minutes during the two-hour working period a sample of exhaled air was collected and analyzed to determine the calories being expended per minute.

The subjects were weighed in and out each morning. The resting periods started at 8 o'clock. In order to equalize for the subjects the process of getting used to the experimental conditions, the following order of noisy and quieted days was followed: first week, quieted; middle two weeks, full noise; last week, quieted.

The female subjects were not experimented with for four days before and after menstruation.

Experimental Findings

Energy Consumption.—The average increase of the working metabolism over the resting metabolism was 52 per cent. when the noise was deadened by the acousti-celotex panels, as contrasted with an average increase of 71 per cent. when the noise was not quieted by the use of sound absorbing panels. This is a saving of 19 per cent. of the energy consumption above the resting requirements which can be credited to the quieter condition. Or, expressed differently, there was 19 per cent. more energy consumed by the typist when working under the noisy conditions.

It is somewhat difficult to say just what metabolic factors are at work causing the increased energy expenditure. Undoubtedly, however, there is dissipitated energy. It is probable that even under the most favorable conditions more energy is expended

than is really needed, and this margin of excess energy is apparently increased under the noisy conditions. The introspective observations of the experimental subjects would indicate that under the noisy conditions there is a general dissipation of this excess energy, the excess being spent not only in striking the keys harder but in a general tenseness of the entire musculature. A general heightening of muscular tonus throughout the whole body may be the principal cause of the 19 per cent. increase in energy expenditure.

Speed of Work.—There are two groups of records on speed of work: (1) time of typing a letter, or strokes per minute, and (2) time for removing a completed letter and inserting a new letter.

The average time for typing a letter under the noisy conditions was 162 seconds, as compared with 155 seconds when the noise was reduced approximately half by the absorbing panels. This represents an average gain in speed of 4.3 per cent. when the noise is reduced.

Not all of the subjects were affected alike in speed. In energy expenditure increments they were remarkably uniform. Arranged in order of average typing speed we note the following:

Initials	*Rank in Speed*	*Increase in Speed When Noise Was Reduced* %
R. M.	slowest	0.0
H. B.	next slowest	0.8
P. F.	second fastest	3.6
H. K.	fastest	7.4

It appears that the speedier the worker is, the more adversely his output is affected by the distractions of noises.

In the time required to remove a completed letter and insert a fresh sheet of paper we find a range from 20 seconds for R.M. to 1.8 seconds for H.K. The subjects were affected somewhat differently, although on the average the paper was inserted a half second faster under the quieted conditions. The slowest typist, R.M., however, changed the paper more quickly under the noisy conditions. His introspections indicate that when the siren or the bell happened to sound as he was changing paper he was much quicker. All the other subjects were quicker in changing the paper under the quieted conditions, and all were slowed up especially by the siren or the bell, just the opposite of R.M. If we eliminate R.M. from the averages, we find that the papers were inserted a second and a half faster under the quieted conditions.

Errors Made.—About 1,300 strokes were made for each letter. Errors were computed on the basis of wrong or incomplete strokes. These averaged about four per letter, although some typists consistently made ten or more such errors in each letter typed. The two slowest typists were slightly more accurate under the noisy conditions; the two fastest typists were slightly more accurate under the quieted conditions. These two tendencies exactly balance each other when an average is struck for the experimental squad.

Fatigue in Output.—The average time required for the first five letters and that required for the last five letters written in each experimental period were compared in order to ob-

tain a record of speeding up or slowing down during the noisy and quieted conditions.

Under the quieted conditions at the close of the two-hour period of work the average time per letter was seven seconds less than at the beginning of the period. With the noise machine unquieted by the absorbing panels the speed per letter at the close of the period was five seconds slower. All the subjects were similarly affected. Under noisy conditions there is no apparent "warming up," and each succeeding letter takes a little more time than the one before it; while under the quieted conditions a slight amount of speed is actually gained in each succeeding letter.

Fatigue in Energy Expenditure.—An unexpected trend in the data was found in the calorie calculations made each fifteen minutes during the work period. It had been anticipated that with continued work under adverse conditions the energy expenditure might gradually increase. We were somewhat surprised to discover that the energy expenditure differences between the noisy and the quieted conditions were the same after the first fifteen minutes of work as they were after two hours of intensive work.

Summary of Findings

In many nonhospital cases the physician could apparently consider the working environment of the patient in cases of obscure neurasthenia and fatigue. The experiments on office conditions seem to indicate that in some instances a move to a quieter workplace may be as good as a rest, there being a difference of 19 per cent. in the energy expenditure increment following working in a noisy as compared with a quieter environment. Men and women seemed to be similarly affected, while the more skilled typists were adversely affected in output to a greater extent than were the mediocre typists.

CHANGES IN THE BLOOD PICTURE UNDER THE INFLUENCE OF LEAD, AND THEIR IMPORTANCE IN THE DIFFERENTIAL DIAGNOSIS*

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INTRODUCTION

EARLY diagnosis, which plays an important part in the prognosis, therapy, and even prophylaxis of a considerable number of diseases, is of still greater importance in cases of chronic industrial intoxications, since by a timely application of therapy we are almost always enabled to prevent the development of a severe condition of chronic poisoning in the patient and to take measures toward preventing the poisoning of the entire group of employees who are working under the same conditions. Naturally, therefore, the question of the early diagnosis of industrial intoxications has become the object of study on the part of many investigators.

Views on Significance of Blood Findings

Lead poisoning is a menace in many well-known trades and for that reason is one of the most important of industrial poisonings. On the basis of a group investigation of workmen in the various lead industries, and of detailed study of separate clinical aspects of the picture of lead poisoning, K. B. Lehmann (1), Teleky (2), Schmidt (3), and others ascribe greater or less significance to the blood findings as an early manifestation of plumbism.

According to Oliver (4), anemia, which is progressive at first and later may change to cachexia, is a characteristic sign of lead poisoning. Zangger (5) and François (6) report the diminution in percentage of hemoglobin as one of the early manifestations—a finding which has been confirmed by the work of the Russian investigators at the Ukrainian Institute of Industrial Medicine (7), the Institute of Obuch (7), and elsewhere. The hemolyzing property of lead, and the consequent development of anemia, is not denied by anyone at the present time. Still under discussion, however, and described from different points of view by a number of authors, are the questions of the morphologic peculiarities of lead anemia, its specificity, its causes, and its importance in the differential diagnosis. These questions involve in the first place a discussion of the so-called basophilic granular erythrocytes, concerning which there exists an extensive literature recording experimental as well as clinical findings.

Basophilic Granules.—Schmidt (3) and Trautmann (8) found basophilic granular erythrocytes in normal blood; Trautmann in 21 per cent. of 100

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healthy persons. Ferrata (9) maintains that normal blood does not contain basophilic granules, and that they are seldom met with in anemias other than that caused by lead poisoning. Studying the morphology of the blood in experimental poisoning, he failed to obtain basophilic granular erythrocytes when he injected phenylhydrazine, iron, amyl nitrite, and other poisons; he did, however, find a large number when he introduced lead. On the other hand, Hans Lehmann (10) observed a large number of basophilic granular erythrocytes in the blood of guinea-pigs after subcutaneous injection of alcohol and after oral administration of glycerin, coal dust, and cement.

We could cite here many more investigations which discuss the specificity of basophilic granular erythrocytes. The majority of authors, among them Teleky, Schmidt, and K. B. Lehmann, are, however, not convinced of the absolute specificity of this finding, as there is no doubt that basophilic granules are not observed in lead poisoning only, as is confirmed also by the results of our studies.

The controversy in reference to this question may thus be considered at present as settled; this does not, however, preclude the importance of the presence of basophilic granular erythrocytes as one of the valuable signs of lead poisoning. Teleky, Schmidt, and others, in their group investigations of workmen in various lead industries, have always looked for this sign and have regarded it as an important one, counting the granular erythrocytes according to the schedule introduced by Schmidt, who considered the finding of 100 basophilic granular erythrocytes in 1,000,000 red blood cells as pathognomonic for lead poisoning. On the other hand, some of the recent studies are attempting to divest this sign of even its relative specific importance. We would mention in particular the experimental works of Hans Lehmann and the investigations of the Obuch Institute, where basophilic granular erythrocytes have been found in the blood in various industrial intoxications, such as those caused by lead, carbon disulphide, arseniuretted hydrogen, and nitric oxide.

Although we do not exaggerate the importance of basophilic granules or consider their presence as absolutely specific for lead poisoning, we do believe, however, that we must not underestimate their diagnostic value as a sign of lead poisoning. On the basis of our studies we consider it possible to introduce the term "practical specificity" of the presence of basophilic granular erythrocytes in the blood of workmen in the lead industries. Before passing to a detailed report of our findings which served as the basis for such deductions, we will describe briefly the technic employed in our study.

Clinical Study

Technic Employed in Blood Examinations

The hemoglobin determination was done with the Sahli-Bervald hemometer; the smears were fixed for three minutes in methyl alcohol and were then put into Giemsa's stain for five minutes (1 per cent. solution: 1 drop to 1 c.c. of distilled water). For the count of basophilic granular erythrocytes, the smears were placed for five

minutes in an aqueous solution of methylene blue (1 per cent. solution: 1 drop to 1 c.c. of distilled water); for the thick drop of blood, we used an aqueous solution of methylene blue and carbolfuchsin (5 drops of methylene blue to 10 c.c. of distilled water and 4 drops of carbolfuchsin). The count was made from the thin smears; an ocular 3 Zeiss lens was used, each microscopic field being considered as covering 300 erythrocytes.

Groups Investigated

Our material covers 381 cases, classified into groups as follows:

I. Workers who come in contact with lead:

a. Two groups of workmen, paint grinders, in two factories. In the first factory there were 32 men; in the second factory, 45 men.

b. Two groups of workers in the ceramic industry, who handle glaze. In the first factory (Tversky) there were 28 workers—12 men and 16 women; in the second factory (Volchovskoy), 25 workers—12 men and 13 women. All the men in these groups were between 20 and 50 years of age.

Groups a and b were investigated at their places of work.

c. Twenty-one compositors examined at our policlinic. These men were referred to the clinic for consultation at different times by various organizations.

d. Eleven patients placed in our clinic for treatment because they gave manifestations of one or another form of lead poisoning: 2 compositors, 7 paint grinders, 1 glass blower, and 1 workman at the white lead factory at Iaroslavl.

II. Workmen who do not handle lead directly:

a. One hundred and five workmen in the hot trades (stokers, smelters, hammermen, and molders).

b. Forty-two workmen handling rubber, who come in contact with benzene.

c. Sixty-seven workmen in gas generating stations, who come in contact with carbon monoxide.

d. Two cases of mercury poisoning, one in a workman from an electric light factory, the other in a laboratory worker who purified mercury by boiling it.

e. Three cases of hydrogen sulphide poisoning in workers in a chemical factory.

Group I. Workers Who Come in Contact with Lead

a. Paint Grinders.—In paint grinding there are two important stages: first, mixing the dry paint powder with oil in a special mixing funnel; and, second, the thorough mixing of the paint with oil on a roller machine. The work is carried on without any special ventilating or protective equipment and naturally, therefore, there must be a considerable amount of dust.

At the time of our investigation in the first factory, the paint grinders were working with white lead and red lead. In the second factory, no lead paints were used, zinc paints having been substituted two months previous to our investigation.

The average length of time spent in this occupation by the workmen in the first factory is ten months (the factory has been in existence only a year and a half); the average length of time spent in this work by the men in the second factory is four years, but a great many of the men have worked at this occupation for ten to twenty years. In spite of the greater amount of time spent in the work by the second group, we note that the more serious pathologic manifestations in the blood are to be seen in the first group. In 20 of the 32 men in the first group, the hemoglobin is below 80 per cent.; only 23 of the 45 men in the second group show any diminution—all to below 80 per

cent. The percentage of men suffering from anemia is thus slightly higher in the first factory than in the second. The number showing basophilic granular erythrocytes is many times larger in the first group than in the second (21 out of 32 in the first group; 3 out of 45 in the second group).

Rauch and Michaelis (11), in experiments on rabbits, have shown that the basophilic granular erythrocytes disappear from the blood within three weeks after exposure to lead ceases. If we consider the fact that for two months previous to our investigation the workmen at the second factory had not been in contact with lead, then it becomes apparent that our findings coincide with the experimental results reported by these authors. It is hard, however, to believe that the lead which the workmen of the second group had been absorbing over a period of several years had all been eliminated from the organism during the two months. Minot (12), who made a special study of this question of the elimination and the distribution of lead in the tissues of the organism, reports that lead is deposited in large quantities in the bones and in the liver. Evidently the appearance of basophilic granular erythrocytes is connected not only with the presence of lead in the organism but also, and to a greater degree, with the time of its entrance into the circulation. This fact will be confirmed by a number of data given later in this study. Here we wish only to point out that in quite a large percentage of cases in the second group we have found a number of other manifestations of lead poisoning of a more permanent character, such as, for example, the lead line and the diminution of hemoglobin; in no case, however, was a hemoglobin percentage below 70 observed.

Thus, to sum up, we noted a diminution of hemoglobin in both groups of paint grinders in a relatively large number of cases. We found basophilic granular erythrocytes in a large number of cases in the first group, who were working with lead paints at the time of our investigation, and in only a few cases in the second group, who were investigated two months after the men had ceased working with lead.

b. Ceramic Workers.—We investigated only workers engaged in the glazing process, in which red lead and white lead are used—workers who prepare the glazing material and those who cover the crockery with glaze. We visited two factories: the Tversky, named after Kalinin, and the Volchovskoy.

Diminution of hemoglobin to below 80 per cent. was noted in 6 out of the 12 men at the Tversky factory, and in 7 out of the 12 men at the Volchovskoy factory. At the Tversky factory the hemoglobin percentage did not fall below 70; at the Volchovskoy factory in 6 out of the 7 cases it was lower than 75 and in one case it even reached 60, which for a male is considered a sign of very pronounced anemia. In the Tversky factory, 15 out of the 16 women gave a hemoglobin figure of less than 80 per cent. but in no case was a diminution to below 70 per cent. noted. At the Volchovskoy factory all the 13 women workers showed hemoglobin below 80 per cent.; in 10 it was below 70, and in 4, below 60 per cent. From these figures it is evident

that anemia is more prevalent at the Volchovskoy factory.

Turning to the morphology of the blood, we found polychromatophilic cells in the thin smears (more than 100 per 1,000,000 erythrocytes) in only 3 cases in the Tversky factory, while in the Volchovskoy factory increased polychromatophilia was found in 21 of the 25 workers. We did not find any basophilic granular erythrocytes in the thin smears taken at the Tversky factory (in the thick drop we found them in 4 of the 28 workers), but at the Volchovskoy factory we found some in 18 of the 25 workers.

General clinical investigation did not reveal even 1 case of lead poisoning at the Tversky factory, while at the Volchovskoy factory 3 cases with clinically pronounced manifestations of plumbism and a few suspicious cases were found.

Interested in the reasons for such a wide difference in the blood picture and in the results of the general clinical investigation of the workmen in similar occupations in the same industry but employed at different factories, we undertook a more detailed study of the processes of the industry. We found that the methods of preparing the glaze are not the same in the two factories. We cannot dwell here in detail on the question but wish only to point out that lead may enter into the preparation of glaze either as a fritted ingredient or as partly fritted and partly unfritted material. The fritted material is a mass melted in special ovens at 1,200° and consists of lead (red lead, from 20 to 30 per cent., and white lead) and other ingredients (kaolin, borax, etc.) from which the glaze is prepared. According to the reports of American authors (A. Hamilton (13)), the lead in the frit is so firmly bound, as a result of melting, that any possibility of free lead compounds arising in excess of 5 per cent. is excluded. This is the way in which the glaze is manufactured at the Tversky factory, the lead entering into the glaze as a chemical compound only. At the Volchovskoy factory, on the other hand, the process is somewhat different; after the frit is prepared by practically the same method as that just described and before it is run into the special drums in which it is mixed with water in order to prepare liquid glaze, white lead and red lead (in small quantities) are added. A mechanical mixture is thus formed which, after drying, forms dust containing free lead compounds (white and red lead).

c. Compositors.—Twenty-one compositors were examined at our policlinic. Diminution of hemoglobin to below 80 per cent. was noted in only 2 cases and basophilic granulation in only 4 cases.

d. Patients in Attendance at Clinic.—Having concluded the statements of results obtained by us from the examination of the groups of workmen who come in contact with lead but are able to continue at work, we pass to the analysis of Group d—11 clinical patients who were incapable of work and who were suffering from one or another form of lead poisoning.

Patient P., aged 36 years, a glass blower from an electric light factory, was suspected of having been poisoned by mercury with which he came in contact in the course of his work. He was referred to the clinic by the medical control committee for a more

detailed examination. His complaints were: general weakness, giddiness, and constipation followed by diarrhea.

Physical Examination.—The patient showed extreme grayish pallor of the skin and the mucosa, the gums were tender and hemorrhagic, and along the margin of the lower incisors there was a narrow grayish-blue line. The blood pressure was 145 systolic and 90 diastolic. The abdominal wall was tense; the deep reflexes were exaggerated.

Blood Examination.—The blood findings were as follows: hemoglobin, 62 per cent.; erythrocytes, 3,200,000; basophilic granules, 1 per 1,000 erythrocytes; erythroblasts, 1 in the smear. Pronounced polychromatophilia (++++) was noted. The leukocyte count was 7,300 (differential count: lymphocytes, 31 per cent.; mononuclears, 6 per cent.; eosinophils, 5 per cent.; neutrophils, 62.5 per cent.).

The clinical picture is clearly not typical for mercury poisoning, and upon making a more detailed investigation of the industry we found that shortly before the onset of P.'s illness a glass with a high lead content, unusual for this kind of manufacture, had been used at that particular factory where he was employed making glass pumps. Thus in this case, as in the study of the ceramic workers, the blood picture attracted our attention and directed it from the workman to the processes of manufacture.

In only 2 of the remaining cases of clinically expressed saturnism did the blood smears fail to reveal basophilic granular erythrocytes. In the other 9 cases, including patient P., basophilic granules were found to a greater or less extent. If we turn to the histories of the 2 cases above mentioned, we find that, unlike all the other patients, who usually came to the clinic direct from the factory, these men had ceased to work—one six months and the other about a year previous to entering the clinic.

Summary of Data for Group I

Analyzing the results obtained from the group examination of workmen who were exposed to lead and of the clinical cases reported above, we must note in the first place the presence of anemia in a considerable number of cases (as shown by the diminution of hemoglobin). In the first group of paint grinders it was observed in 63 per cent. of the entire number studied; among the group of compositors, however, the hemoglobin was below 80 per cent. in only 2 of the 21 men examined. Evidently the kind of lead and the compound used, particularly with respect to its solubility, plays an important part here. Naturally salts of lead (white lead) are more soluble than metallic lead such as is used in the printing trade. According to statistics, compositors occupy the least hazardous place among the occupations in which lead poisoning is encountered. Teleky (2) notes a comparatively small number of cases of saturnism among miners, who also come in contact with metallic lead only. The morphologic changes in the blood picture (polychromatophilia and basophilic granular erythrocytes) usually found in lead poisoning are also less frequently found among compositors than among other lead groups.

In addition to diminution of hemoglobin, we also find basophilic granular erythrocytes in a large number of cases: in 21 out of 32 in the first group of paint grinders; in 3 out of 45 in the second group of paint grinders; in

18 out of 25 in the group of workers in the second factory in the ceramic industry; and in 9 out of 11 in the group of clinical patients. In the other groups, this sign was observed in only a small number of cases. We have already dwelt in detail on the factors that might have caused this variation in the findings.

Passing to the question as to how far the influence of lead may be connected with the diminution of hemoglobin, with the finding of basophilic granular erythrocytes, and with polychromatophilia, we can see from the material already submitted that after lead is removed from the manufacture, as in the case of the second group of paint grinders, the basophilic granular erythrocytes disappear within a short time. The difference in the blood pictures presented by the two groups of ceramic workers led us to a more detailed study of the conditions of work of these groups, and we found that while the workers in the first group were not exposed to free lead, the workers in the second group, owing to the special conditions under which they worked, were exposed to the influence of free lead.

Thus we see that with consistency and regularity we can note anemia and the presence of basophilic granular erythrocytes in workers who are exposed to lead. These peculiarities in the blood picture of workmen in the lead industry become still more pronounced when we compare these findings with those from workmen in other industries. We are in a position to submit here data of an investigation of three groups of workers who do not come in contact with lead in the process of their work but who are exposed to other industrial poisons.

Group II. Workmen Who Do Not Handle Lead

Among the 105 workmen in the hot trades, who were investigated at our clinic, there were 20 with hemoglobin below 80 per cent. and 2 with basophilic granular erythrocytes; among the 42 workers in the rubber industry there were 10 with hemoglobin below 80 per cent. and 2 with basophilic granular erythrocytes; and in the third group, 67 workers in gas generating stations, there were 18 with hemoglobin below 80 per cent. and 3 with basophilic granular erythrocytes.

Workers in the hot trades are exposed to the effects of high temperature as well as to sudden changes in temperature, the rubber workers are exposed to the effects of benzene, and the workers at the gas generating stations (especially at one station investigated by us) are exposed to the effects of illuminating gas; still they give a small percentage of cases with diminution of hemoglobin, as compared with the lead workers, and a very small percentage of cases with basophilic granular erythrocytes; moreover, in these cases there was only 1 basophilic granular erythrocyte in the smear, while among the lead workers we had cases where as many as 15 per 1,000 normal erythrocytes were found.

In the 2 cases of mercury poisoning and the 3 cases of hydrogen sulphide poisoning, we had a clearly expressed clinical picture of the poisoning and of anemia but could find no basophilic granular erythrocytes.

Practical Specificity of Blood Picture in Lead Poisoning

The following comparison shows to what extent we can consider anemia, and especially the finding of basophilic granular erythrocytes, specific for the occupations that are exposed to the influence of lead. This "practical" specificity, certainly, does not exclude the possibility of the appearance of basophilic granular erythrocytes under the influence of other causes, a number of instances of which took place in our clinic.

Our data show that basophilic granules were noted in cases of secondary anemias, where we have irritation of the bone marrow due to the destruction of erythrocytes under the action of some toxin (*e.g.*, malaria, cancer). A pronounced polychromatophilia was also noted in these cases. Even in cases of diseases such as malaria and cancer, the appearance of basophilic granules is a far less constant symptom than in cases where the patients have been exposed to lead. G. I. Baradulin (14), studying the morphology of the blood in neoplasms, found basophilic granules in only 4 out of 72 cases of cancer, and in all these cases anemia was very severe (below 2,000,000 erythrocytes). Besides, the differential diagnosis with these diseases (malaria and cancer) is not difficult, as here we always have a clear picture of one or the other disease.

At the same time we must emphasize that in the few cases where we found basophilic granules in the blood of men not working in lead industries we always noted diminution of hemoglobin, *i.e.*, anemia, while in workers in the lead industries we sometimes found a high percentage of hemoglobin along with basophilic granular erythrocytes, not only in our group examinations of practically healthy individuals but also in cases where we had one or another form of clinically expressed saturnism. In men not working in lead industries, there was not one instance of basophilic granules without anemia. We cannot, therefore, agree with Trautmann (8) and Schmidt (3), who believe that in normal individuals not exposed to the influence of lead we can often find basophilic granules. We think that Ferrata (9) is correct in his statement that under conditions of normal regeneration, such as takes place in healthy persons, no basophilic granules are to be found.

With regard to chronic industrial intoxications with poisons other than lead, we have already seen, in our Group II investigations, that the groups exposed to carbon monoxide and to benzene did not give any considerable number of cases in which basophilic granular erythrocytes were found, and that in the 2 cases of mercury poisoning and the 3 cases of acute hydrogen sulphide poisoning, where we had a clearly expressed clinical picture of the poisoning and of the anemia, we could find no basophilic granular erythrocytes.

Hans Lehmann (10), however, came to just the opposite conclusion as a result of a recent study. By means of injection, feeding, and inhalation experiments on guinea-pigs, with alcohol (10 to 50 per cent.), cement dust, glycerin, coal dust, and lime dust, he succeeded in producing basophilic granules in the same amounts as when

he introduced lead, if not in greater amounts. He gives as his motive for choosing these substances the fact that the majority of industrial workers are exposed to their influence, thus showing that he intended to apply the results of his experiments to men. In 1925 he published a paper on the effects of alcohol, and we tried to check his work from the point of view of the morphology of the blood. We injected alcohol in the same dose and of the same concentrations (1 c.c. of 10 per cent., 1 c.c. of 40 per cent., and 1 c.c. of 50 per cent.) into three guinea-pigs, but obtained no basophilic granules. Even if we agree with Lehmann, however, and consider that by his method basophilic granules could be obtained experimentally, it is hardly possible to apply the results to men, as he tries to do. He calculated that according to weight a man must drink 177 c.c. of 40 per cent. alcohol in order to cause basophilic granules to appear in his blood, but since workmen often drink even more, it is difficult to tell whether the presence of basophilic granules is due to the influence of lead or to the influence of alcohol. This way of putting the question cannot satisfy us. Workers in the lead industries do not differ very much from workers in other industries as far as their use of alcohol is concerned; yet basophilic granules are more often found in the lead workers, while in workmen who are exposed to lime and coal dusts we do not find any basophilic granules. If we look over the groups mentioned above, we can say with certainty that workmen in the hot trades (according to their histories) consume more alcohol than do the paint grinders and the workmen in the ceramic industry; still we find basophilic granules only in exceptional cases in the blood of the workmen in the hot trades and as a rule in the blood of the paint grinders and the ceramic workers.

TABLE 1.—RESULTS OF TWO INVESTIGATIONS OF THE BLOOD OF A GROUP OF SEVENTEEN PAINT GRINDERS

NAME OF WORKMAN	FIRST INVESTIGATION—WHEN LEAD PAINTS WERE BEING MANUFACTURED		SECOND INVESTIGATION—TWO MONTHS AFTER WORK WITH LEAD PAINTS HAD STOPPED[1]	
	Percentage of Hemoglobin	Basophilic Granules per 1,000 Erythrocytes	Percentage of Hemoglobin	Basophilic Granules per 1,000 Erythrocytes
L. I.	84	1.0	86	0
P. P.	80	0.1	91	0
K. C.	74	1.0	80	0
G. Sch.	70	1.0	83	0
K. N.	73	0.5	85	0
D. I.	68	8.0	90	0
E. C.	80	1.0	87	0
P. C.	71	1.0	74	0
P. B.	68	1.0	80	0
U. N.	62	15.0	77	1
P. N.	72	1.0	87	0
N. I.	70	12.0	78	0
A. C.	82	0.1	71	0
T. G.	77	1.0	76	0
S. V.	88	0.1	80	0
K. V.	70	1.0	70	0
I. A.	81	2.0	78	0

[1] Six months after the first investigation.

Thus, the experiments of H. Lehmann cannot refute the fact, which has been demonstrated not only by our studies but also by the results of in-

vestigations of groups of lead workers published by K. Lehmann and Teleky, that half and sometimes more of those examined showed basophilic granular erythrocytes. The question brought forward by H. Lehmann must be decided, not through experiment, but through examination of different groups of workers, and that is what we have tried to do in this study.

Passing to the question of the persistence of lead anemia, we are in a position to present here data of a repeated investigation of one group of paint grinders, consisting of 17 men who at the time of the first investigation, six months previously, showed the presence of basophilic granular erythrocytes (see Table 1). Two months previous to the repeated investigation the factory discontinued the production of lead paints and started to work with zinc paints. In 16 out of the 17 cases we find an entire disappearance of the basophilic granular erythrocytes, without any relation to the amount in which they had been noted at the first investigation. Along with the disappearance of the basophilic granules we note the rise in the percentage of hemoglobin in 12 out of the 17 cases. If we are to accept Lehmann's point of view, this change in the blood picture is inexplainable, inasmuch as the workmen had not stopped drinking.

Thus our clinical studies give us the right to regard lead anemia in respect to its "specific" symptoms (basophilic granules), as well as in respect to the diminution of hemoglobin, as transitory, provided the workman is removed from the factory or provided the use of lead is stopped, in spite of the fact that in some cases we have the picture of a severe anemia and a number of other symptoms (*e.g.*, lead line and rise in blood pressure).

Experimental Study

Having determined the "practical specificity" of the changes in the blood in lead poisoning in clinical material, we shall pass to a review of these changes in experimental animals. For our studies we have used guinea-pigs poisoned with lead; in these animals all the changes appear very soon and in a very severe form.

Procedure

For the experiment eight full-grown guinea-pigs were used. Several preliminary examinations of the blood were made. The blood counts were done with smears fixed with methyl alcohol and stained with an aqueous solution of methylene blue in order to bring out the basophilic granular erythrocytes and the polychromatophilia. For the count of the leukocytes and the erythroblasts Giemsa's method of staining was used. The erythroblast count was done on a basis of 100 leukocytes and was then reduced to a basis of 1,000 erythrocytes. The count of basophilic granules and of polychromatophils was also done on a basis of 1,000 erythrocytes. Besides the staining of fixed smears, we also used the so-called vital staining, *i.e.*, we made the blood smear on a previously stained glass slide, and in this case the smear was not fixed. The poison used was 1 per cent. lead nitrate. The injection was made subcutaneously every four to five days. On the same day the analysis of the

blood of the animals and the checking of their weights were also done.

Experiments with Small Doses of Lead.—According to the dose of the poison used, two types of poisoning were apparent. In the first type, poisoning caused by a small dose of lead, every four to five days 0.01 gm. of lead was injected; altogether, during twenty-five to thirty days, 0.1 gm. was injected.

The first sign of the reaction of the bone marrow in response to the injection of the poison is the increase in the number of polychromatophilic erythrocytes. At that time no marked diminution in the percentage of hemoglobin or in the number of erythrocytes is to be noted; sometimes even on the fifteenth to seventeenth day of the experiment, when the count of polychromatophilic erythrocytes reaches 25 per 1,000 erythrocytes, the percentage of hemoglobin, as well as the number of erythrocytes, rises. Starting from the twentieth day, the number of polychromatophilic erythrocytes begins to fall and at the same time more and more basophilic granules (up to 85 per thousand), as well as erythroblasts and megaloblasts (*i.e.*, elements of embryonic blood), begin to appear. At the time of the appearance of the latter forms, we evidently have a case of incapacity of the bone marrow. From this point on, the normal blood formation is replaced by blood formation of the embryonic type. In view of the fact that more and more of these abnormal forms appear in the blood, the general blood picture becomes worse each day, though the injection of lead is stopped. Owing to its slight solubility, the lead continues for a long time to pass into the organism from the places of injection. At these places we usually find infiltrates. Not until twenty to twenty-five days after the last injection does a gradual rise in the number of erythrocytes and in the percentage of hemoglobin start. At the same time the number of polychromatophils begins to increase and the number of basophilic granules and of erythroblasts to decrease; *i.e.*, the blood formation again passes to the usual regenerative type.

As we see, the dose of lead here was small but the reaction on the part of the blood passed very rapidly. On an average the hemoglobin fell from 90 to 50 per cent., and the number of erythrocytes from 4,500,000 to 2,800,000. In spite of this, in almost all the cases the blood returned to normal in two and one-half to three months after the beginning of the experiment.

Experiments with Large Doses of Lead.—The second type of poisoning was caused by large doses of lead—0.025 gm. at a time, altogether 0.2 gm. being injected.

During the first five to six days the number of polychromatophilic erythrocytes rises noticeably, mounting as high as 25 to 30 per thousand. After the tenth day, however, the number of polychromatophils begins to fall and the number of basophilic granular erythrocytes begins to rise rapidly, reaching 50 per thousand. In spite of such a rapid reaction on the part of the bone marrow, no sharp fall in the number of erythrocytes or in the percentage of hemoglobin is noted; not until the twenty-fifth to the thirtieth day of the experiment does a decrease set in, and then it is only gradual (a

fall of 10 to 20 per cent. in the hemoglobin). At the same time the number of polychromatophilic erythrocytes and the number of basophilic granules also begin to decrease. Soon after this the animal dies.

Here we have the picture of degeneration of the bone marrow, to such an extent that it is incapable of sufficiently supplying the peripheral blood even with embryonic elements. If the basophilic granules were of a degenerative nature, such a "degeneration" would hardly diminish in the general blood picture at the time when the general condition of the animal and of its blood had become worse.

In the examination of sections, some fatty degeneration of the cells of the liver was noted. The reaction for iron was positive in the liver as well as in the red marrow (hemolysis). The red marrow of the breast bone and of the epiphysis of the femur, though it appeared quite active, presented small portions of necrosis which gave the iron reaction. Between the bone trabeculae conglomerations of cell elements were found consisting of myeloid elements as well as of megakariocytes.

Character and Origin of Pathologic Erythrocytic Forms

Now we shall try to describe in detail the forms of erythrocytes that appeared and their genesis.

Polychromatophilia.—A first sign of the reaction on the part of the blood forming organs in response to the injection of lead was the appearance of an increased number of polychromatophilic erythrocytes; this characteristic was noted by us when we studied our clinical material.

A large number of polychromatophilic erythrocytes are always found in the bone marrow. The erythroblasts of all stages are polychromatophilic. The younger the form is, the more pronounced is the basic character of the protoplasm for taking on stain. In embryos and infants also the number of such cells in the peripheral blood is very large. In adults who are not anemic, only single polychromatophilic erythrocytes are found, but in cases of anemia due to loss of blood, to infectious diseases, to intoxications, etc., and in all cases where there is a diminution of blood for one or another reason, polychromatophilic erythrocytes are found in large numbers. Such conditions permit us to consider these elements as young forms in the regeneration of the blood (Naegeli (15, p. 116), Pappenheim (16), etc.).

Reticulated Forms.—Coincident with the increase in polychromatophilia, there is always an increase in the number of erythrocytes with the so-called substantia reticulofilamentosa; these forms appear very clearly when the vital staining method is used, and they look very much like the basophilic granules of the fixed smears. But the finding of substantia reticulofilamentosa in every blood smear, in a greater or less amount, and, on the other hand, the comparatively rare finding of basophilic granules in the fixed smear, constitute the difference between these two findings.

Schilling (17) considers polychromatophilia, as well as the basophilic granules, of protoplasmic origin and identical with the substantia reticulofilamentosa of the unfixed smears. In his opinion, when the blood is stained in the thick drop, the substantia fila-

mentosa appears very clearly as a network (reticulum) and shows the number of polychromatophilic erythrocytes in the blood, *i. e.*, the extent of regeneration. He denotes the number of these reticula by plusses (+, ++, etc.). The thick drop method consists in staining an unfixed smear with an aqueous solution of the stain; this means that the blood is hemolyzed and all the solid parts remain on the slide. The quantity of these parts depends on the thickness of the drop. The appearance of the reticulum in the thick drop is identical with that of the substantia reticulofilamentosa, and in cases where there is a large amount of substantia reticulofilamentosa in vitally stained smears, and of polychromatophilia in fixed ones, the amount of the reticulum in the thick drop also appears very great.

Finding the method of expressing the polychromatophilia by plusses not exact enough, in our clinic we have lately begun to stain unfixed smears, which have been well dried—for twenty-four hours and more—with aqueous solutions of stains; when such a method is used, the so-called reticulum in the stroma of the erythrocytes appears very well stained. According to its outside appearance and when a count is made, in each microscopic field, it corresponds exactly to the reticulum of the substantia reticulofilamentosa of the vitally stained smears. Evidently we have here, not some special substance that takes on the stain intensively at the "destruction" of the cell, but simply a substance that dissolves in the fixative. According to the opinion of Dietrich, Sabrazès, Pappenheim (18), and Maximov (19), the reticulum of the substantia filamentosa consists of lipoids. If this view is to be accepted, then it becomes clear that, when smears are usually placed for fixation, the lipoids are dissolved, and the reticular part does not get stained. If we examine closely the fixed and stained blood smears of guinea-pigs poisoned with lead, we can clearly distinguish that the polychromatophilic erythrocytes are not evenly stained, as are the orthochromatic erythrocytes, but have on their surface a net-like structure which appears much paler; evidently we have here empty spaces that remained after the lipoids became dissolved. As confirmation of the increase of lipoids in the erythrocytes of animals poisoned with lead, which consequently have a greater number of polychromatophilic erythrocytes, we cite here the work of Kretschmer and Frieder (20), who found a considerable increase of cholesterin in the erythrocytes in lead poisoning as compared with the contents of cholesterin in the plasma; *i.e.*, a relation that is quite the reverse of the normal condition.

The presence of an increased number of these reticula whenever there is an increase in polychromatophilia allows us to consider these findings of the same order, *i.e.*, called forth by the process of regeneration. This view is further confirmed by the fact that these substances are found in great amounts in the blood forming organs as well as in embryos.

On the basis of the foregoing statements, we consider polychromatophilia as of regenerative character. As is seen from the protocols of the experiments, in every instance the first sign of the influence of lead on the blood was increased polychromatophilia.

Polychromatophilia is noted in all the secondary anemias; evidently an increased proliferation of young erythrocytes from the bone marrow takes place. This is normal regeneration. But with the further penetration of the poison, the destruction of the red cells evidently becomes so great that the loss cannot be covered by the regular processes of blood formation; the number of polychromatophilic erythrocytes begins to decrease and at the same time there are thrown out into the blood stream young elements that are usually found in the embryonic blood, *i.e.*, basophilic granular erythrocytes, erythroblasts, and even megaloblasts.

Basophilic Granules.—In normal adults no basophilic granules can be found in the blood or in the bone marrow. In the embryonic period, however, basophilic granular erythrocytes are found in all animals and in man (Ferrata (9), Askanazy (21)) just at the time when the first generation of non-nucleated cells appears (Ferrata). The number of basophilic granular erythrocytes in embryos sometimes reaches 70 per cent. of the entire number (Naegeli (15, p. 124)). The fact that the appearance of these erythrocytes in great numbers in the animals poisoned by us follows immediately after the appearance of a large number of polychromatophilic erythrocytes—young cells—allows us to accept the same point of view on the regenerative nature of basophilic granules as that held by Naegeli (15, p. 123). Moreover, the fact that these embryonic elements appear in the blood stream indicates an abnormal function of the bone marrow: the bone marrow changes its normal function of blood formation to the embryonic function. Such a condition may truly be considered as pathologic regeneration as a result of extreme irritation of the bone marrow.

On the basis of literature on this subject, it may be supposed that wherever basophilic granular erythrocytes appear we have the entrance of products of hemolysis into the blood. In the case of pernicious anemia we have destruction of the erythrocytes in the blood stream (increase in the color index); in lead poisoning destruction of the erythrocytes takes place and a pronounced siderosis is found in sections of the liver and the spleen; in the case of malaria the parasite also destroys the erythrocytes in the blood stream. In the case of internal hemorrhage, and when hemoglobin preparations are taken as medicine, the appearance of basophilic granules can be explained by the absorption of these products. Also when animals are experimentally bled (Blumenthal and Morawitz (22)), siderosis in the spleen takes place. Evidently under the influence of some factors, destruction of the erythrocytes occurs. In cases where we give arsenic, perhaps we also have to do with the hemolytic qualities (Schustrow (23)).

Aside from reports dealing with the question of the regenerative or the degenerative character of basophilic granules (Schilling (17), Grawitz (24)), a considerable amount of literature has been dedicated to the question of the nature of basophilic granules—whether they are nuclear or protoplasmic.

Pappenheim believes that basophilic granules come from the paraplasm of the nucleus; Schmidt (3), Koch (25), and Rauch and Michaelis (11) consider that they are due to the breaking up of the nucleus. In the smears taken from

our experimental animals at the time when the number of basophilic granules in the blood was highest, we could see, as is stated by Koch, the exact time when the granules begin to separate from the nucleus. In some cells the connection between the nucleus and the granule could be clearly seen. Sometimes a few larger granules lying in one group could be noted, which by their position reminded one very much of the nucleus. In any case, it can be said with certainty that the granules are connected with the disappearance of the nucleus from the cell. Granules in the erythrocytes are found in embryos during the period when the first generation of non-nucleated cells appears (Ferrata (9)); their appearance in the peripheral blood occurs at the same time as that of nuclear elements—remnants of small parts of the nucleus, Jolly's bodies, and Cabot's ring-bodies. These forms are found in the smears obtained from our experimental animals. The bone marrow, as a result of the urgent demand for restoring blood elements to the peripheral blood, begins to throw out cells with remnants of the nucleus; *i.e.*, the disappearance of the nucleus does not take place as under normal conditions, and only normoblasts and megaloblasts, which are also common in embryonic blood formation, appear. The belief that there is a connection between the appearance of basophilic granules and the disappearance of the nucleus is also supported by the experiments of Sabrazès and Speroni (26) with birds—pigeons and chickens—in which no disappearance of the nucleus occurred and no basophilic granular erythrocytes were ever obtained. Neither could any granules be noted in the megaloblasts, where the protoplasm is extremely polychromatophilic; but these cells do not lose their nuclei.

The opponents of the nuclear theory point to the difference in the ways in which the granules and the nucleus take on stain when stained according to Romanowsky's method. The nucleus becomes red and the granules blue. When methyl green pyronin is used, the small dots are red and the nucleus is bluish green. But according to the investigations of Domarus (27), Speroni, Sabrazès, and others, pyknotic nuclear elements very often change their usual color. Cabot's ring-bodies and Jolly's bodies also take on a different color from that of the nucleus though these bodies are of undoubted nuclear nature.

Thus, in the guinea-pigs which were poisoned with lead just as in our patients who were suffering from lead poisoning, we note that as soon as the poison ceases to enter the body the regeneration of the blood begins, and it usually proceeds very rapidly. Here, perhaps, we have a confirmation of the point of view offered by Ritz (28), that whenever we have an anemia caused by the introduction of poison it disappears much more quickly than an anemia caused by bleeding, owing to the irritation of the bone marrow by the products of destruction of the erythrocytes. Thus from the studies made on our animals we find that the appearance of basophilic granules under the influence of lead is only one of the symptoms of the general changes in the blood picture, or, rather, is an expression of the condition of the bone marrow and its function.

Next the question arises, whether or

not it is possible to introduce any numerical index, like the norm offered by Schmidt (3), in order to express the extent of the lead poisoning. If we are to make a possible analogy between the findings in the blood of the experimental animals and those in the blood of the workmen, and if we suppose that the examination of the blood of the workmen is done when the bone marrow is in a state of incapacity, as was the case with one of our guinea-pigs, the small number of basophilic granular erythrocytes will not be a sign that the poisoning is not very severe but will indicate, rather, quite the opposite.

We have dwelt on the red blood cell picture in our experiments, for in it only could any definite observations be made. With regard to the leukocytes, we could obtain nothing definite. The variations in the number of leukocytes were very small. In the differential count, a diminution in the number of lymphocytes and a comparative increase in the number of neutrophils were noted in only two guinea-pigs in the severest stage of the poisoning; the eosinophils also decreased or even disappeared altogether at that period. Moreover, we have not succeeded in determining any definite connection between the changes in the resistance of the erythrocytes and the increase in the number of pathologic forms in the blood.

Conclusions

1. Basophilic granular erythrocytes are elements of the embryonic blood; their appearance in the peripheral blood shows a pathologic condition of the blood, as they are results of pathologic regeneration (of embryonic type).

2. Basophilic granules may be found in the peripheral blood under the influence of lead as well as in cases of anemias which are not caused by lead.

3. Basophilic granular erythrocytes appear in the blood of workmen in the lead industries even before the onset of anemia, when the percentage of hemoglobin is still high, as an early reaction of the organism to the influence of lead.

4. Basophilic granules appear only in rare cases in the blood of workmen who do not come in contact with lead, and then they always accompany a severe anemia (primary or secondary).

5. Thus the appearance of basophilic granules must be regarded as "practically specific" for workmen in the lead industries.

6. Basophilic granules are, evidently, connected with the period of entrance and circulation of the lead in the blood, and not with its presence in the places where it is usually deposited (liver and bones).

7. The anemia that usually develops in a workman in the lead industry, if it is caused exclusively or largely by the action of lead, disappears very quickly after the workman is removed from the industry or after he stops working with lead.

8. One of the most frequent diseases among workmen in the lead industries is anemia.

9. The appearance of basophilic granules in the erythrocytes is closely connected with the time when the nucleus is lost by the erythrocytes.

10. The substantia reticulofilamentosa of the erythrocytes is clearly to be distinguished when the smear is stained

by the vital method; it is of lipoid origin, and can be made clearly visible on dry, unfixed smears when they are stained with aqueous solutions of stains.

11. Basophilic granules are of nuclear origin.

12. Polychromatophilia is of protoplasmic origin and can be regarded as evidence of the young form.

13. Following the injection of small doses of lead into guinea-pigs, pathologic forms appear in greater numbers, a characteristic which proves a very good regenerative power of the blood.

14. When large doses of lead are used, there may be a small number of pathologic forms in the blood; this characteristic proves a poor regenerative power of the blood and may lead to the death of the animal.

15. The norm offered by Schmidt has not sufficient scientific foundation and is useless for practical application, for in each individual case the question of removal of the workman from the industry must be decided by consideration of the general condition of his organism.

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HEALTH HAZARDS IN THE COTTON INDUSTRY

(Continued)

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Dust

Just as high temperature and humidity constitute the principal menace to the health of the worker in spinning and weaving rooms, so in the preliminary processes of preparing the raw cotton for further manufacture the principal militating factor is the generation of dust. While all processes in cotton manufacture are more or less dusty, as is evidenced by the continuous cleaning required to keep the various machines free from fluff, and while the processes of gassing, knotting, and dry weaving sometimes produce dust in sufficient quantities to be noxious, the workers engaged in mixing, opening up, and carding have to put up with a variety so objectionable that they experience, as I have previously shown, a special liability to develop diseases dangerous to life. Since the preliminary operations have completely removed the heavy dust incorporated with the raw cotton, the later processes of combing, drawing, roving, spinning, and winding produce nothing save a slight fluff made up of very short fibers.

Sources of Dust.—The amount of dirt which is contained in the raw cotton, and which necessarily has to be removed, varies with the quality of the staple, the coarser varieties containing most. Where bale breaking is still a hand process, the worker has to put up with a considerable quantity of dust, but where the modern method of employing a mechanical bale breaker for this work is in vogue dust is not nearly so much in evidence. In mills spinning low counts, where much mixing takes place, it is still a common practice to place moderately sized slabs, taken from the selected varieties in their proper proportion, on to a feeding lattice attached to the breaker, and in such case an amount of unavoidable dust gets into the atmosphere. Ordinarily the bale, either whole or divided into only two or three parts, is placed directly into the hopper of the breaker, and the amount of dust that gets into the atmosphere under these circumstances depends on whether the broken-up product is passed on by lattice or by exhaust tube. The first mode of transit produces a slight cloud at the back of the machine but the second, which involves a closed-in rear, is practically dustless. Dust also rises when the automatic feed hopper of the opener is fed by lattice or by hand, but not when the feed is by exhaust. Openers and scutchers are exceedingly well covered in machines, and have always

an inside negative pressure as the cages are fitted with exhaust ducts and fans, so that there is little risk of any air pollution from these sources.

Although modern cards are enclosed, there are several points where dust escapes, so that in most circumstances there is a tendency toward a hazy atmosphere; unless the cotton is very dirty, however, any actual density of the mist, or its actual presence in some cases, is mostly a matter of insufficiency or inefficiency of ventilation. A considerable amount of noxious dust arises from the brushing of the flats, but the most intensive clouds are produced by the stripping of dirt and waste from the carding and doffer cylinders. This process of stripping is mainly carried out by a revolving brush, the wires of which are brought into close contact with those of the cylinder and doffer, the thick layer of waste being subsequently removed from the brush by hand. Up to quite recent times the process was carried out in the open, the stripper getting the full benefit of a concentrated supply of the worst type of dust, but owing to the modern provision of a closely fitting tin cover with an exhaust attachment this evil condition no longer obtains in Lancashire. Dust is still in evidence, however, when the covers become badly fitting, through wear and tear, or when the exhaust becomes inefficient. The vacuum is now usually produced by chamber and air pump, though there are still some instances where it is obtained by fan. A newer method of stripping, which is coming very much into favor, is worked on the lines of an ordinary vacuum cleaner, the suction mouthpiece traversing the length of a spindle fixed over the cylinder operated upon and keeping in close contact with the wires. This is quite efficient, provided that a stripping brush is used once each week in addition. Stripping is carried out from twice to four times a day, according to the class of cotton being carded.

The process of grinding the wires of the two cylinders is effected by means of a revolving carborundum or emery covered disk, which traverses the length of a steel rod in each direction in turn and so sharpens the wires on both sides. The operation is carried on without cover, but as the dust is not very dense and as the grinder is not obliged to be in attendance during the process, the risk of inhalation is infinitesimal. That no general danger is created is shown by a recent report by Middleton (17), which states that the particles of abrasive thrown off are too large to do any damage. The grinding of each card takes place at intervals varying from a week to a fortnight.

A very dusty proceeding is the clearing away of the waste and dirt from the receptacles beneath the cards, openers, and scutchers, the jobber having to work in the midst of a thick cloud. The ordinary method of cleaning the machines by brush and waste also drives a certain amount of dust into the air. Other sources of dust are the gassing frames, where doubled yarn is passed through a series of bunsen gas jets to singe off projecting fibers, and the operation of twisting up or "knotting" hanks of yarn for parceling. In the latter operation the hank is placed on a steel bar and pulled sharply to straighten the threads. The dust

which troubles dry weaving sheds consists of particles of size from the warps, and this variety is much in evidence in the warehouses of wet sheds where the plaiting machines throw off considerable quantities.

Nature of Dust.—The dust arising in the various sections of cotton manufacturing, though mainly coming within Arlidge's (18) classification of "vegetable," does, in the preliminary processes of preparation, during weaving, and in the manipulation of the finished cloth, contain a considerable proportion of mineral matter—a circumstance which cannot be overlooked when considering its effects on the workers. The quality of the individual dusts varies with the nature of the different dust producing operations. In breaking up the bales, a process which involves the pulling asunder of large pieces of compressed material, the dusty product consists mainly of short fibers; the opening and scutching processes, which necessitate pulling asunder, severe beating, and aspiration (blowing) of the compressed pieces, bring away a considerable quantity of seeds, husks, and sand, as well as broken fibers; carding, which separates the individual fibers, produces a dust made up of short and knotted pieces (neps), seeds (bearded motes), broken husks, and other vegetable material, as well as a considerable quantity of fine sand. Samples of the sand, taken from the dirt box beneath a carding engine, which were placed under the microscope showed metallic particles, vegetable débris, cotton fibers, spores, conidia and hyphae of molds, bacteria, sand particles, and a considerable number of crystals of silica of all sizes and shapes. My friend Mr. S. Hodgkinson has very kindly made for me a series of analyses of both Egyptian and American varieties of this cotton dust, and his most recent results are set out in Table 7.

TABLE 7.—QUANTITATIVE ANALYSIS OF AMERICAN AND EGYPTIAN COTTON DUST

	AMERICAN	EGYPTIAN
	%	%
Moisture at 100°C	5.52	7.32
Dry dust:[1]		
Organic matter and CO_2	34.66	48.16
SiO_2	49.98	29.09
$Fe_2O_3+Al_2O_3$	8.55	14.06
CaO	2.91	3.90
MgO	0.175	1.23
SO_3	0.87	1.149
Undetermined	2.855	2.086

[1] Inorganic matter (ash?) contained traces of Cl and P_2O_5 (American) and P_2O_5 (Egyptian).

Though the samples when looked at with the naked eye appeared to be sand only, the analyses show that organic matter made up a very big proportion of the bulk. What is also important, they indicate that the mineral part consisted mainly of silica. The fact that free silica, though shown to be present by the microscope, is crowded out by organic matter and some combined silicon helps to explain the harmlessness of the sand as a producer of silicosis. A magnet proved the presence of particles of steel, presumedly due to the grinding, and this would account for a considerable proportion of the iron oxide found in the tests. Middleton's (17) recent

investigations on the nature of card room dust show the rough composition to be practically as given above. With regard to his actual atmospheric estimations, he is of opinion that his findings are not likely to prove of much value, as the pollution was so variable in amount.

The nature of the dust generated in other processes has been indicated, but it is worth noting that the dust from plaiting weighted cloth is largely made up of china clay.

Effects of Dust.—Making an exception for the moment of card room and blowing room hands, I believe I am right in expressing the view that the excessive prevalence of bronchitis among cotton operatives generally is mainly a matter of temperature and humidity, or rather of the influence exercised by these factors on the production of catarrhal colds. The difference shown by Table 2 between the incidence in males, whose work is almost entirely in the card and blowing rooms, and in females, who form the bulk of the workers in all departments except mule spinning, together with the greater liability to catarrhal colds evidenced by the latter, gives strong support to this contention. The dust in spinning and other departments may have some tendency to create irritation, but it should be well within the power of the ciliated respiratory mucous membrane to deal with such dust, so that any influence which it can have on the production of bronchitis must be regarded as only contributory. Females in dusty card rooms, blowing rooms, and mixing rooms are, I believe, affected directly, though not to the same extent as the men; but I have nothing to prove this beyond my personal knowledge of the processes and of the workers.

Both the mortality figures quoted and my own morbidity table demonstrate distinctly that male operatives in the carding and blowing departments are particularly liable to bronchitis. Cleaning out the dirt boxes beneath the machines, and, to a lesser degree, leaky brush covers, are in my experience the factors mainly responsible for this susceptibility today. Though such statistics as are available class the effects of the dust of these departments under the term "bronchitis," there is no doubt that the symptoms which one notices in strippers at work are those of asthma. I have seen a number of cases during recent years, and all have exhibited the classic symptoms described long ago. There is pronounced dyspnea, which is distinctly asthmatic in character and of a thoracic type; there is a dry, irritative cough, and the expectoration, very little in amount, is very sticky and difficult to get rid of; during the attacks there is seen the expression of countenance so typical of patients with asthma. A very noticeable feature of the complaint is the complete disappearance of the symptoms during the week-end at home, their rapid return on a Monday morning, with the resumption of work, and their subsequent though gradual easing down again during the course of the week; cleaning out a dirt box will invariably bring on an acute attack.

Professor Collis (19, p. 260), when medical inspector of factories, made very exhaustive investigations into the nature, extent, and prevention of "strippers' asthma," and the modern

method of removing the dust by exhaust is the result of his findings and recommendations. At that time the evil result of working at the process was so inevitable and the wrecking of the respiratory organs so pronounced that he found few old men in this employment. Only 139 out of every 1,000 working were of the age of 45 years and over, as compared with 231 metal grinders and 434 lace workers. In the later stages he noticed loss of flesh, the change over from diaphragmatic to purely thoracic respiration, the increasing prominence of the sternum, the development of the barrel shaped chest, and emphysema. He further found that among men working in coarse grades of cotton 91 per cent. were more or less affected, among those working on medium grades 72 per cent., and among those working on fine grades 62 per cent. These extreme cases are rarely seen today, and indeed it is now quite common to come across strippers well over 50 years of age still employed at their trade.

In imperfectly ventilated gassing rooms the atmosphere is quite hazy from the charred particles floating about, and the odor of burnt cotton is disagreeably pronounced. The dust is very irritating and I find that girls suffering from blepharitis, or subject to conjunctivitis or catarrhal conditions of the respiratory mucous membrane, are markedly affected. Workers in ordinary health, however, soon get acclimatized to this irritation and discomfort, though I have noticed, among those who have been working under disagreeable conditions for a considerable length of time, a distinct tendency to anemia and a particular liability to complain of symptoms of headache, dizziness, and lassitude. I have long held the opinion that these latter symptoms are the result of imperfect removal of the unburnt products of the bunsen gas flames, and that carbon monoxide is probably the offender. I am supported in this contention by an investigation, made some little time ago by the Manchester Air Pollution Board, which showed that a bunsen gas fire gives off two and a half times as much carbon monoxide as an experimental coal fire.

The dust generated in the processes of hank knotting, in dry weaving, and in the making up of heavily sized cloth produces symptoms suggestive of irritation of the air passages, the most pronounced being a dry, irritating cough. Warehousemen in wet weaving sheds seem to be particularly liable to bronchitis.

Preventive Measures.—In the preliminary breaking up and decompressing of the raw cotton, dust is very successfully prevented from polluting the atmosphere by placing the unbroken or partly broken bales directly into the hopper of the bale breaker in the first instance, and by subsequently conveying the cotton to the openers by exhaust ducts. The openers and scutchers are now very efficiently closed in, and the dust abstracted by the blowing process is carried away from the cages by a system of ducts which discharge into a chamber fitted with an air shaft to prevent back pressure. In most Lancashire card rooms, the dust problem is being satisfactorily dealt with, though the coarser varieties of cotton appear to be still providing a considerable amount of trouble in some factories.

The freer use of humidifiers seems to be effective in these bad cases, but the operatives do not favor this method and, personally, I agree with them. If properly taken in hand, ventilation should do all that is necessary. Extraction fans are very much used in card rooms, mostly drawing directly, often through the medium of ducts and overhead hoppers, and sometimes *via* ducts communicating with floor grills fixed in front of the machines. It is, of course, essential that inlets be provided of sufficient area to balance the pull of the fans, and this is usually accomplished by fixing hoppers in the windows. In some instances propeller fans are installed to help the extractors, but the advantage to be gained by this method is not quite clear. Some card rooms are fitted with propulsion fans and ducts, either with or without a humidifying chamber attached. Personally, I have been impressed with the efficiency of extraction through ducts, and it certainly appears logical to gather in the dust at a point in close proximity to the machine and the worker instead of drawing it across the room.

The methods of cleaning away the dust and the fluff deposited on the machines in card and blowing rooms are deserving of attention. The ordinary procedure is to remove the bulk with a hand brush and to polish off with a handful of loose waste, though obviously this system must succeed admirably in retransferring the dust to the atmosphere. I have seen vacuum cleaners working very efficiently in gassing rooms and I believe that they have been adopted in some card rooms. I certainly think that this method will be universally adopted in the future for cleaning cotton machinery, not only because it cleans without throwing the dust into the air but also because it is such an excellent safety first device for the protection of tenters against accidents from gears, straps, and pulleys. An American method of cleaning away dust and fluff from cotton machinery by compressed air jet does not appeal to me; though it is safer than hand cleaning, it must necessarily, like this out-of-date operation, drive the polluting material back to the atmosphere.

The satisfactory way in which the really dangerous dust of card rooms has been dealt with is one of several remarkable examples of what master cotton spinners can do to ameliorate bad conditions when they put their backs into the work. Following on Dr. Collis' report (19), the Cotton Spinners' Federation made experiments with various types of local exhaust, and in 1911 an agreement was arrived at between this body and the operatives' organization on the principles which must govern any methods adopted for dealing with this particular evil. The systems that I have explained were the result. If efficiency decreases through breakdown, or weakening of the exhaust, or damage to the brush cover, the remedy is obvious. The cases of asthma which one comes across among men engaged in emptying the dirt boxes can, I find, be quite satisfactorily prevented by the use of a suitable respirator. Men came to see me at my mill clinic who were in the habit of using, of course without benefit, a simple mouth respirator. I therefore obtained samples of several varieties of respirators which would cover

both mouth and nose, and adopted a perforated aluminium and rubber one which can easily be made to fit the curves of the face. A strip of surgeons' lint placed inside this, which can readily be changed as required, collects an enormous amount of dust. A curious feature in connection with this respirator is the manner in which it has been adopted at each mill where I have introduced it. Nobody has ordered the men to wear them, but when a former sufferer has appeared with one and has got through his task of dirt removal with impunity, the other strippers and jobbers have visited the welfare department and asked to be supplied with them. This type of respirator is now exceedingly popular in a number of mills, and this popularity has spread to the men who clean the screens which filter the Manchester atmosphere on its way to the humidifying chambers.

Gassing rooms have been a great source of worry ever since their introduction, but the dust and fumes can now be kept out of the surrounding air space and be satisfactorily conducted outside the building by attaching an exhaust duct to each burner or series of burners. Air inlet ducts are also fixed beneath each frame to obviate objectionable drafts. Such a system, besides purifying the atmosphere, has also proved very successful in reducing the high room temperature which ordinarily results from the process. The introduction of vacuum cleaning for the frames has also proved of great benefit as a means of keeping the dust out of the atmosphere. A modern gassing room is therefore quite a comfortable place to work in. The dust arising from knotting is dense only in the immediate vicinity of the worker; it has been found quite easy to deal with this dust by fixing a hood close to the knotting bar and drawing it by fan and duct into a bag. Dust in dry weaving sheds and in some winding rooms is a question of efficiency of ventilation, and where plaiting machines dealing with heavily sized cloth are the offenders the proper remedy is the establishing of a hood, duct, and extraction fan.

Fatigue

I have no doubt that if one of our modern investigators, skilled in matters of fatigue, could have been afforded an opportunity to study factory workers and their working methods during the last century, he would have discovered plenty of good evidence of the existence of the extreme variety known as "pathologic." The exposure day after day to excessively high temperatures in hermetically sealed spinning rooms, or to the hot and almost saturated air of wet weaving sheds, must inevitably have produced not only a very serious diminution in resistance to disease but a definite and lasting impairment of constitution. The older factory surgeons, particularly Arlidge and the two Pardons, without indulging in a minute study of output, accident rate, or other modern methods, did know something of the effects of industrial conditions on the individual and have fortunately transmitted to us the results of their observations. Arlidge (18), for instance, tells us that "The more observable effects of cotton-spinning on the general health are anaemia and an aspect of debility, of care and anxiety, not consonant with

the age of the workers, who are mostly females, and young. Conjoined with these, and dependent largely on long standing and work in hot and moist apartments, are uterine derangements of various kinds. To long standing also is due the occurrence of varicose veins and ulcers, and of flattening of the arch of the feet." I have, however, made it fairly clear that the cotton operative generally is a much healthier individual today, that females are not exceptionally prone to uterine derangements, anemia, or debility, and I shall proceed to demonstrate that the few systemic investigations that have been recently made do not justify the assumption that this class of worker is particularly susceptible to the effects of fatigue.

Though the general improvement in health has, I believe, been mainly due to circumstances explained elsewhere, I do not propose to ignore the important bearing which the reduction of working hours must have on the whole subject. Indeed, I freely admit that, granted the existence of fatigue in a particular industry, such a measure is the most direct and probably the most effective means which can be taken to effect its eradication. Unfortunately we have nothing in the way of comparative statistics in England to show the direct effect of this important reform on the cotton operative.

Before July 1, 1919, the hours worked were $55\frac{1}{2}$ a week, Saturday taking up $5\frac{1}{2}$ hours, and the other five working days 10 hours each; the spells were 6 A.M. to 8 A.M., 8:30 A.M. to 12:30 P.M. (12 noon on Saturday), and 1:30 P.M. to 5:30 P.M., the half hour and the hour intervals being for meals. On the date mentioned, these were changed to 48 hours a week, made up of a morning spell of $4\frac{1}{2}$ hours, from 7:45 A.M. to 12:15 P.M., and an afternoon spell of $4\frac{1}{4}$ hours, from 1:15 P.M. to 5:30 P.M., with the 1-hour interval for the midday meal, and on Saturday one spell of $4\frac{1}{4}$ hours, from 7:45 A.M. to 12 noon.

One cannot doubt the value of this reduction so far as health and well-being are concerned, but it has one disadvantage to meet as compared with the old system. When the hands commenced work at 6 A.M., it was on an empty stomach, or on one containing only a drink of warm tea, and two hours elapsed before they were able to get a more or less reasonable breakfast. At present the men, as a rule, do get a hurried though mostly unsatisfactory breakfast, but in the case of females the change of hours has not done away with the disinclination for a meal on getting out of bed in the morning. Instead, therefore, of a 2-hour spell on little or no food, there is the prolonged period of $4\frac{1}{2}$ hours to face on a practically empty stomach. This is a serious disadvantage, and is being met by providing hot water for tea brewing between 9:30 and 10 A.M. and allowing opportunity for eating any light food brought by the workers themselves. Some firms provide milk, malted milk, Bovril, or Oxo, at a nominal rate, and serve the two latter with biscuits; also the dispensing of as much as 20 quarts of milk in a morning is not an uncommon experience at a moderate-sized mill. I throw out the suggestion that a reasonable way of meeting this defect would be to commence work at 7:30 A.M. and to stop at 9:15 for fifteen minutes, to obtain refreshment. It is

nevertheless possible that the two meal per day system and the long spell without food have something to do with the well-marked absence of serious diseases of the digestive system among this class of workers. I know a number of mills where interest is taken in the nutrition of the worker to the extent of providing a good meal in the middle of the day at a very cheap rate and this, of course, is a valuable asset to the worker.

It is only recently that the Industrial Fatigue Research Board has taken an active interest in the human factor as it affects the cotton industry. This body published, in 1920, what is apparently meant to be a preliminary treatise on the subject of individual differences in output to be found in various processes of the cotton industry (20), the declared object being to illustrate the extent to which production in each separate process depends upon human as opposed to mechanical efficiency. Due notes were taken of the variation in counts dealt with, and the results were classified under each variety in the groups reviewed. In both mule spinning and ring spinning the chief features were the comparative smallness of the mean variation and the slight differences between the maximum and the minimum values. The obvious conclusion was that the part played by the operative is very minor in comparison with that undertaken by the machine, and that there is, in consequence, very little opportunity afforded for manifestation of individual differences in efficiency. In the processes of drawing, slubbing, and roving, difficulties were experienced in getting reliable data, but the results produced appear to indicate the correct position. They show that the relative importance of the human factor is more pronounced than it is with spinning and less than is the case with weaving processes. As a matter of experience, I find that the human factor is generally regarded as one of some importance in the tenting of drawing frames. There are so many changes of sliver cans and so many automatic stoppages that watchfulness, speed, and dexterity must be brought into play to get the particular defect remedied and the machine restarted with a minimum loss of time, and it is on this account that particular care is exercised in the selection of capable women as tenters.

In considering winding there was some difficulty met with, owing to the irregular degree of importance attached to the process at different spinning mills, and consequently there were many instances where it was necessary to wait for work. Possibly the observation would have been more successful if it had been taken at a series of doubling mills, where there is no waiting for the spinner, where the rule is to arrange the various equipments to allow of several processes keeping pace, and where variation in output is mainly due to variation in the class of work going through. Possibly, however, it was thought desirable to deal with the winding of single yarn, a function undertaken by most spinning mills. The published results show the existence of considerable differences in productivity between the workers.

The amount of wages earned at the several processes investigated was taken as the index of efficiency, and the variations from the average

(100) have been summarized in a final table from which I have taken the extracts given in Table 8. The figures produced are very interesting; although, in the gross, they show the preponderating influence of the mechanical factor on production, they also clearly indicate the extent and the variation of the human influence in the different processes. As was indicated in the case of drawing frames, individuality is a matter of watchfulness, speed, and dexterity, and the qualities are mainly brought into play in those processes which are subjected to the most stoppages. In mule spinning there are no stoppages, except for doffing and cleaning between the creel and the carriage, nor are there any in ring spinning except for doffing and banding. The human quality is mainly exhibited in piecing; creeling is a comparatively minor matter, but doffing is an important event, and when it occurs frequently the speed at which it is accomplished must have a definite influence on the total output. In the intermediate processes, the whole frame is stopped while a broken end is pieced; this means more scope for human efficiency. Although the whole frame is not stopped for piecing up in winding, this process involves so much piecing of ends and changing of bobbins and tubes, while the machine is running, that the daily output is bound to be affected by the degree of efficiency exercised by the winders in carrying out the necessary operations. In clearer winding of doubled yarn the winder needs to be very alert in order to detect and break out faultily doubled, badly twisted, and dirty lengths, and must be both speedy and exact where hand knotting is practised. The process which has always seemed to me to give particular scope for individual efficiency is ordinary single reeling, a quick eye being the essential quality demanded, and I am pleased to note that Dr. T. Yagi of Japan holds the same view (21). All the hanks are taken from the swift at one operation, and those that are short in weight, through want of promptness in detecting and piecing up a broken end, have to be put back and be brought up to weight before a new series can be started. Slackness in this department sadly interferes with earning capacity.

TABLE 8.—VARIATIONS FROM AVERAGE WAGE (100) IN DIFFERENT PROCESSES

PROCESS	WAGE		
	Maximum	Minimum	Mean Variation
Weaving (fancy)	132	65	10.0
Weaving (plain)	126	73	6.0
Winding	119	75	8.3
Slubbing	109	91	4.7
Drawing	108	89	4.0
Intermediate	108	94	3.2
Roving	109	92	2.9
Ring spinning	109	92	2.0
Mule spinning	107	91	1.9

No observations were made on doubling processes, but it appears probable that the demand for the human element would be somewhere between that required for ring spinning and that required for winding.

On the whole, the observations tend to show the extreme difficulty one would have in trying to gauge fatigue

in the spinning industry by output. It could not be done with spinning itself, and winding which appears to have been considered as a process which might present possibilities in this direction has scarcely justified expectations. Want of efficiency in any of the processes dealt with is, of course, no proof of fatigue when unsupported by other evidence.

The Industrial Fatigue Research Board has made some further investigations on bobbin winding, and the report published in 1920 quite confirms my own views (22). The investigators did not find it possible to make any detailed investigations into the output, and a test of the time taken to piece up a range of fifty bobbin ends to fresh ring tube ends, shortly after the beginning of every morning spell and just before the close of the afternoon spell, gave results so varied that they were properly considered to be unreliable. Personal inspections did not bring to light any jaded looks either toward the end of the day or toward the end of the week, and the general behavior gave no indication of physical fatigue. No series of observations was made to test the quality of the work turned out at various periods of the day but the investigation showed how little variation there is in the output of individual workers and in the totals from different days, also how little bad work is likely to be found during any selected period or periods.

That the time of incidence of accidents provides little evidence of fatigue production was clearly demonstrated by Mr. J. H. Crabtree, H. M. Inspector of Factories, by means of details supplied to the Departmental Committee on Accidents (1909), respecting the time of occurrence of 1,000 cotton factory accidents in the Oldham district. Table 9 is compiled from Mr. Crabtree's figures. These figures show quite clearly that, apart from a sharp rise on Tuesday, the increase in incidence rate goes steadily upward

TABLE 9.—DISTRIBUTION OF 1,000 FACTORY ACCIDENTS ACCORDING TO DAY OF INCIDENCE AND TO HOUR OF INCIDENCE

TIME OF INCIDENCE	NUMBER OF ACCIDENTS
Day of Week	
Monday	163
Tuesday	196
Wednesday	150
Thursday	171
Friday	195
Saturday	120
Sunday	5
Total	1,000
Hour of Day	
Forenoon	
Before 6	9
6 to 7	51
7 to 8	93
8 to 9	36
9 to 10	70
10 to 11	150
11 to 12	134
Afternoon	
12 to 1	48
1 to 2	19
2 to 3	50
3 to 4	112
4 to 5	107
5 to 6	65
After 6	12
Time not stated	42
Total	1,000

toward the end of the week. The 120 accidents which took place on Saturdays would practically all happen before 11:30 A.M., when the engine stops for cleaning throughout the mill, *i.e.*, during a working period of five hours; this is equivalent to a daily figure of 240. If there were definite contemporary evidence that cotton spinning processes produced fatigue, this section of the table would certainly support it, but, in the absence of this evidence, one is justified in attributing the excessive rise on Saturday to overanxiety to get through with the cleaning and to the surreptitious efforts toward doing this which are made before the engine stops. The hourly incidence does not provide any strong evidence of daily fatigue. Certainly the sixty-five accidents between 5 and 6 P.M. would take place between 5 and 5:30 P.M., which would be equivalent to 130 for the full hour, but again the nervous tension produced by the drawing to a close of the day's work would be quite a likely explanation of the increased rate during this particular half hour. The high rate between 10 A.M. and noon can scarcely be an indication of fatigue. It is curious that after the first hour and a half of each of the long spells the accident incidence should rise so materially, but there is a possible explanation of this in the likelihood that the workers, after going steadily for this period, cease to think out their actions and allow them to become automatic.

The figures from the Operatives' Approved Societies quoted in Table 3 show that lost time on account of sickness is not too serious a matter, and apart from this cause of absence, the worst time losers are married women, who are particularly apt to stay away for domestic reasons; but no comparative figures showing lost time at different mills and their several departments are available in England. Labor turnover is a very small factor during normal times, and only develops to any extent among workers between 14 and 16 years of age. Actually it is quite a common experience to find operatives of mature age who have spent all their working days at the mill; indeed, I have certified as suitable for superannuation women who have worked over fifty years for one firm.

When temperatures are excessive, *i.e.*, over 90°F., one does come across spinning room operatives showing definite signs of fatigue, mainly, of course, toward the end of the day's work. It would also appear that mule spinners still suffer to an abnormal extent from varicose veins, varicocele, and flatfoot. Personally I am not convinced that the processes are monotonous, but I will admit that the close attention which must be given to the work may have an effect on some proportion of the female workers. I sometimes come across a woman tenter who complains of headache and nervous depression but I generally find that a holiday effects the necessary cure. I am, however, inclined to think that temperament has most to do with these cases.

In the matter of static fatigue, due to prolonged fixation of certain muscles as a result of having to work in a strained position, the inquiry into bobbin winding (22) showed that

any strained position taken up was only temporary and that the ill effects were quickly rectified. Winders have to practise a certain amount of back bending and, where seats are not provided, are on their feet all the working day, but, generally speaking, they keep fairly well on the move; the same can be equally well said of the workers at the other processes discussed.

The lifting and dragging of heavy skips and tins still requires some rectification. Provision should be made for this work to be done in all cases by men or well-grown youths, and the most sensible practice is to move the skips from point to point on low bogies running on tramlines. The most a girl should do is to empty and fill these receptacles, or to carry sets in her arms or empty bobbins in her apron. It is also wrong for growing girls to carry even 27-pound laps from scutchers to cards. They rarely attempt to get into the way of using each shoulder alternately, and are consequently liable to produce some degree of lateral curvature of the spine. Even where bogies capable of conveying six laps are provided I frequently find card tenters carrying their own. An excellent system which I have seen in use consists of a mechanical conveyor, working from the blowing room and along one wall of the card room, to which the full laps are attached vertically and so carried to within a short distance of the cards. The laps are lifted from this conveyor by the tenter and replaced by empty rods for return to the blowing room.

The only systematic investigation of any definite value which the Industrial Fatigue Research Board has so far been able to carry out on the incidence and extent of fatigue in the cotton industry is described in the report on "Variations in Efficiency in Cotton Weaving," published in 1923 (8). The object as stated was "to determine the nature and general effect of the factors which influence the efficiency and fatigability of the operatives" and the findings add materially to our knowledge of this aspect of cotton weaving. Efficiency is shown to depend upon two main factors: *viz.*, the number of loom stoppages and the ability of the operative to attend to them. Yarn breakages are the principal causation of stoppages, and the more numerous these become, through physical defects in the yarn or through adverse atmospheric conditions, the greater is the loss in efficiency and any impairment of the normal working capacity of the weaver brings about a still further reduction. All the various factors affecting the yarn, the machine, and the individual are exhaustively dealt with, but as I am concerned only with the item of fatigue, and this has been admirably isolated from its somewhat complicated surroundings, I must restrict myself to this alone.

Fatigue is measured by a very ingenious method. The working capacity of a loom is usually expressed in terms of picks per minute, *i.e.*, the number of times the shuttle crosses the loom in that period, and these picks can be registered by a pick recorder. If no stoppages take place in a loom during a given period, say one hour, the recorder will show the full number

of picks for that loom, which would be 12,000 if the rate was 200 per minute, and would constitute a standard output for that loom. If, owing to time lost by stoppages, only 9,000 picks are registered as actual output, efficiency would be expressed as 75 per cent. and the time taken up in rectifying stoppages would be fifteen minutes. It is only during the fifteen minutes of repairing stoppages that the human element comes into play, the other forty-five minutes being a matter of the machine entirely. If the next hour showed 72.5 per cent. this would indicate a decrease of only 2.5 per cent. in loom efficiency, but the time occupied in piecing up is increased 10 per cent., which, if all working conditions were the same during the two periods, may be taken as showing a decrease in human efficiency to that extent. If the period of highest working capacity in a day or a week is taken and the percentage of time spent attending to loom stoppages is assessed, it is easy to make comparison between this figure and figures obtained in a similar way for other periods, provided the loom is weaving the same cloth and is being run under the same conditions of temperature and humidity.

Taking a suitable shed for the purpose of working out this scheme, Wyatt was able to demonstrate that the highest efficiency is manifested on Tuesday morning, after a low efficiency on Monday, and that there is a steady decrease during the rest of the mornings of the week; also that efficiency is much less during the afternoon spells, and steadily diminishes during these periods from Monday to Friday. The percentage decreases are shown as follows:

Day	*Percentage Decrease in Working Capacity*	
	a.m.	*p.m.*
Monday	1.6	5.5
Tuesday	0.0	6.2
Wednesday	1.1	6.3
Thursday	1.5	6.7
Friday	2.3	7.5

It is suggested, and I think quite reasonably, that this daily decrease can be assigned to cumulative fatigue caused by incomplete recovery from daily fatigue, except in the case of Monday morning when the low efficiency is due to the process of getting into a stride. Taking hourly variations, the efficiency peak is found to be in evidence during the hours 8:15 to 9:15 and 9:15 to 10:15, and there is a steady decrease for each subsequent hour, except during the period between 1:30 and 2:30, just after the dinner stoppage, when there is a jump back to the highest level; the drop, however, commences sooner in the afternoon than in the morning spell. The figures are as follows:

Time	*Percentage Decrease in Working Capacity*
8:15 to 9:15	0.0
9:15 to 10:15	0.0
10:15 to 11:15	1.0
11:15 to 12:15	4.8
1:30 to 2:30	0.0
2:30 to 3:30	5.1
3:30 to 4:30	7.2
4:30 to 5:30	12.7

These changes in the working efficiency of the weaver are put down to "the relative effects of the accumulated

fatigue during the course of the working day." I should perhaps mention that as conditions of temperature and humidity must be uniform for each series of observations, half days and hours had to be selected where such conditions obtained, so that the results are representative of what Wyatt terms a "composite" week and a "composite" day.

Certain other points were brought out by the investigations. The tendency is for the drop in efficiency to commence at an earlier period during each successive day of the week; work in dry sheds appears to be more fatiguing than work in wet sheds; conditions of work are more fatiguing in summer than in winter; although the number of yarn breakages decreases with the increase of temperature and humidity, the reverse is the case with the ability of the weaver to mend them, so that after a certain point is reached production diminishes.

Maloney's Indian observations (4), though not carried out to the extent of analyzing out from efficiency losses the percentage which might be attributed to fatigue, certainly show a marked diminution in output during hot weather in all cotton processes where machines are stopped for repairing of breakages, and also that the coolest period of the day at this season provided the highest efficiency figures. The processes referred to are weaving, slubbing, intermediate roving, and fine roving, and of the last three, fine roving exhibited the greatest variation. Maloney found very little difference in spinning efficiency, the worst month, July, being only $2\frac{1}{2}$ per cent. below November, the best month. The effect of the reduction of working hours on efficiency is well demonstrated. In May, 1920, the hours were reduced from eleven and one-half to ten a day, and though production suffered at the commencement, after a few months the weaving output was the same as before the alteration and the spinning output improved by about 10 per cent. though it could not reach the previous gross amount.

Twisters' Cramp

In the Report of the Chief Inspector of Factories for 1919 (23), Dr. Bridge describes a disability occurring in the weaving branch of the industry as the result of overworking a particular set of muscles; this overwork produces a permanent condition of the hand which either prevents the worker from continuing his employment or precludes him from earning his former wage. The operatives affected are known as twisters, loomers, or twisters-in, and their work is to join the ends of a new warp to the warp ends of a woven piece. A warp is commonly made up of between 2,000 and 2,500 threads, each of which is passed through an eye in the center of a heald for the purpose of being raised or lowered to form a "shed" for the passage of the shuttle. When a warp is finished, the ends may be drawn out of these eyes and the ends of a new warp drawn through, or the threads may be kept in position and the new warp ends attached to them by the process of twisting. Though in some cases this process must be carried out at the loom, it usually takes place in another room. The operator, sitting in a frame with the old warp on one

side and the new warp on the other, takes a number of threads from each and passes them through a ring attached to a waistbelt; he then lifts one thread with his left thumb, and taking up an opposite one with his right index finger brings it into contact with the first between his left thumb and index finger; the ends are then broken from their ring attachment and twisted together between the left thumb and index finger. A skilled worker may twist together as many as 2,000 ends in one hour. Muscles of the left forearm as well as of the thumb and index finger are involved in a somewhat complex series of movements, the actual operation of twisting demanding a fixation effort from the muscles of the various phalanges of the index finger as well as contractions of the thumb muscles.

The subjective symptoms are pain, referred to the base of the thumb and rarely spreading to the arm, tenderness of the muscles, weakness and loss of power of the thumb; actual cramp is apparently rare. The principal physical sign is an unusual flattening of the thenar eminence of the palm. The men become affected at various periods ranging from five to thirty-five years after commencing this work. Bridge believes that the condition is due to a central nervous lesion, as in other occupational neuroses, and in addition that there is created a local fibromyositis of the thumb muscles, which may be the chief factor in those cases where work can be continued.

As a considerable amount of this particular work, as well as "drawing through," is now done mechanically, the natural tendency should be for the disability to fade away.

Lighting

Inasmuch as bad lighting has not hitherto been officially recognized by any Factory Acts as an insanitary condition, one need not be very much surprised that it should be so prevalent in most of our factories, more particularly, of course, during the dark hours of the day when artificial illumination has to be utilized. In cotton factories one can easily conceive that the concentration of machinery and consequent risk of accident, together with the particularly fine nature of the material dealt with, would demand close attention to lighting; and although this has been the case to a greater extent than in many industries, so far as concerns the admission of daylight, there is much leeway to be made up in the matter of adequate artificial illumination. In spinning processes the continuous watching of the long succession of rows of delicate threads, and, in weaving, the close attention which must be given to the warps are particularly conducive to eyestrain, and the intensifying of this condition is a natural sequence to poor lighting.

Except in some one-storied card rooms the natural lighting of English spinning factories is provided by windows. The modern spinning mill is well provided with window space, usually reaching to the ceiling and divided up by little more than pillars of brickwork, but owing to the length of the present day mule the rooms have to be constructed of a width which, in many cases, prevents direct

light from reaching the center. This is particularly the case in lower stories and where neighboring buildings create obstruction. At some of the older mills where new machinery has been installed, it has been necessary to fix the mules lengthwise of the rooms, with the result that the machines themselves block the main sources of light. In ring spinning mills this excessive width is not required, and therefore the lighting is often much better. The practice of placing mules and frames transversely is solely with the object of allowing the light to penetrate the alleys or "gates" without obstruction.

The Factory Act insists upon periodic whitewashing or painting, and, apart from cleanliness, it is essential for good lighting that this requirement should be strictly observed. It is also highly important to make sure that the windows are not handicapped by external obstructions to light and to attend to their regular cleaning. I have no knowledge of prismatic glass being used for cotton factory windows, but in cases where there are obstructive buildings I am inclined to think that it could be fixed with distinct advantage. In the 1923 Report of the Chief Inspector of Factories (24) mention is made of a successful application of the system to the five floors of a large factory, a good light, it is said, being projected to a distance of 80 feet from the windows. The basement of the Manchester College of Technology is lighted in this manner, and thirty years ago I very successfully applied the principle to the lighting of my own surgery. In weaving sheds, which are universally of one story, roof lights facing north are invariably adopted. There are cases, however, when the placing of these sheds close to taller buildings, for the purpose of protection against dry winds or for other reasons, has produced a bad effect on the lighting power of this otherwise excellent system. In practice this obstruction of daylight means an earlier resort to artificial lighting during the winter months, with the attendant disadvantages.

Artificial illumination is mainly provided by electricity, vacuum lamps being commonly used though the gas filled variety are now coming well into vogue; high and low pressure gas with mantle burners is, however, still much in evidence. In card and blowing rooms the lights are fixed usually from 10 to 12 feet above floor level, and for slubbing and roving frames about 7 feet above the floor; in mule spinning rooms the height is 7 feet or a little over, and for ring spinning and ring doubling, 7 feet or a little less. The usual height for plain weaving is from 6 to $6\frac{1}{2}$ feet, and for jacquard and dobby looms, a little higher. In mule rooms a double row of lights is placed along the mule gate, each row being above the center line of a range of threads when the particular carriage is at the extent of its outward run; frames are lighted by a row of lights above the alleyway separating two sets. With regard to spacing the lights in a given row, I have experience of instances where they have been so allocated that the outer rays of one cross those of the next at a point 6 inches above the line of work to be illuminated; this means, in the

case of mule threads $2\frac{1}{2}$ feet from the floor, that the lights should be 8 feet apart at a height of 7 feet. So far as I can ascertain, however, spacing is not ordinarily carried out on such systematic lines. In weaving sheds the lights are placed with the object of illuminating the warps, usually one lamp to two looms or one higher power lamp to four looms.

The Third Report of the Departmental Committee on Lighting in Factories and Workshops (25), published in 1922, details some experiments on the degree of efficiency of lighting in cotton factories, and one may conclude from these that the systems in vogue must be regarded generally as unsatisfactory. In card rooms, which include drawing and roving frames, ninety photometric observations were made and the results give the mid figure as 0.9 foot candles; a number of observations showed higher illuminations than 1 foot candle owing to the fact that they were taken at a greater height and thus nearer the source of light than most of the others. In spinning rooms, 124 observations were taken at a height varying from $2\frac{1}{2}$ to 3 feet, according to the class of spinning; the mid figure was 0.7 foot candles and there were few records over 1 foot candle. In sheds weaving plain cloth, ninety-four observations produced a mid figure of 1.6 foot candles, 15 per cent. showing figures between 2 and 3 foot candles and 65 per cent. showing figures between 0.2 and 1.2 foot candles. In jacquard and dobby sheds, 108 observations gave the same mid figure as was obtained in plain sheds. Weaving processes were thus found to be better lighted on the whole than were spinning processes. Table 10, abstracted from

TABLE 10.—EFFICIENCY OF ILLUMINATION OBSERVED IN DIFFERENT ROOMS IN COTTON FACTORIES

TYPE OF LIGHTING	MAXIMUM	MINIMUM	AVERAGE
	f. c.	*f. c.*	*f. c.*
I.—Carding, etc.			
Electric vacuum	4.0	0.5	1.3
Electric gas filled	2.5	0.5	1.3
Electric vacuum	1.7	0.5	1.2
Electric vacuum	3.2	0.2	1.1
Electric gas filled and gas inverted mantles	2.0	0.2	1.0
Electric vacuum	1.4	0.2	0.6
Electric vacuum	1.0	0.2	0.5
II.—Mule Spinning			
Electric vacuum	4.6	0.3	1.3
Electric gas filled	1.9	0.6	1.3
Electric gas filled	2.1	0.6	1.1
Gas inverted mantles	2.6	0.4	1.1
Electric vacuum	1.7	0.4	1.0
Electric vacuum	2.9	0.3	0.8
Electric vacuum	1.7	0.2	0.5
III.—Ring Spinning and Doubling			
Electric vacuum	2.5	0.3	0.9
Electric vacuum	2.0	0.2	0.6
IV.—Plain Weaving			
Electric vacuum	3.0	1.2	1.9
Electric vacuum	3.7	1.4	2.2
Electric vacuum	2.0	0.6	1.2
Electric vacuum	1.9	0.5	1.1
Electric vacuum	2.3	0.6	1.2
Electric vacuum	3.4	0.3	1.0
V.—Jacquard and Dobby Weaving			
Electric vacuum	2.9	0.5	1.6
Gas inverted mantles	3.8	0.6	1.4
Gas inverted mantles	5.0	0.6	1.3
Electric vacuum	1.9	0.5	1.1
Electric vacuum	2.2	0.3	0.8
Gas inverted mantles	5.8	2.0	3.7
Electric vacuum	2.0	1.0	1.6
Electric vacuum	2.4	1.0	1.7

Table A of the Report of the Departmental Committee (25), gives the foot candle results for each room where observations were made.

Table 11, abstracted from Table C of the same report, shows the percentage of observations with foot candle values below the foot candle power given at the head of each column. This table sets forth the net results in an exceedingly graphic manner, and that these results are of a really distressing character is readily demonstrated by reference to the conclusions of the Committee on what should constitute a fair minimum standard for industries which require more than moderate illumination. A list of such industries is given under "Fine Work" requiring 3 foot candles and "Very Fine Work" requiring 5 foot candles. Weaving, beaming, winding, and warping of light-colored fine counts, or of dark-colored coarse counts, are placed in the 3 foot candle schedule; weaving, beaming, winding, and warping of dark-colored fine counts, together with twisting in and drawing in by hand, are placed in the 5 foot candle schedule. Spinning, carding, roving, and doubling are not mentioned, but, judging from the American standards quoted, it would appear that carding and roving should require at least 2 foot candles and spinning at least 3 foot candles. The Committee is apparently of the opinion that the different industries should make their own series of experiments, with a view to ascertaining the most suitable lighting standards. As manufacturers are so directly affected financially by the adverse influence of bad lighting on accident risk and output, the suggestion appears quite reasonable, and I certainly think that some such course should be taken in the cotton spinning and weaving industries.

TABLE 11.—PERCENTAGE OF OBSERVATIONS IN DIFFERENT ROOMS IN COTTON FACTORIES WITH ILLUMINATION BELOW SPECIFIED CANDLE POWERS

ROOM	FOOT CANDLE POWER BELOW									
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4
	%	%	%	%	%	%	%	%	%	%
Carding.....	12	30	44	55	72	77	85	92	95	99
Spinning.....	15	35	55	67	85	91	95	98	98.5	99
Plain weaving.	0	9	17	26	45	74	84	91	95	99
Fancy weaving	0	3	13	26	49	74	88	93	96	98

Owing to the universal disregard of the necessity of providing effective shading for lights, glare is a very pronounced factor in all factory lighting systems. Operatives in spinning mills get the glare directly in the eyes when looking, as they are continually doing, the length of a mule carriage or frame for the purpose of detecting broken threads, and they get it obliquely when piecing. Weavers get the glare obliquely when watching their work, and directly whenever they look away from it. This class of defect creates great discomfort for the worker, tends to bring on headaches and ocular fatigue, and certainly demands the introduction of efficient shades.

Another objectionable factor which requires attention is the amount of overhead gloom due to the absence of any attempt at top lighting; the resulting contrast creates further strain on the eyes through overworking of the muscles of accommodation. A few lights with reversed shades not only would cure this but would improve the general lighting of the room.

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(To be continued)

BOOK REVIEWS

How to Make the Periodic Health Examination. A Manual of Procedure. By *Eugene Lyman Fisk*, M.D., Medical Director, Life Extension Institute, and *J. Ramser Crawford*, M.D., Assistant Medical Director, Life Extension Institute. Foreword by Major General Merritte W. Ireland, Surgeon General, United States Army. Cloth. Pp. 393 with appendix, bibliography, and index. New York: The Macmillan Co., 1927.

A great deal is heard these days about the critical importance of periodic "health examinations," but astonishingly few physicians have a very precise idea of procedure involved in a thorough examination of this type. In this book there is presented the experience and method of practice of the Life Extension Institute, an organization devoted to the making of health examinations for the purpose of guiding those of its clients found to have defects of body or mind or faulty habits of living, to the end that they may seek (elsewhere) necessary remedial or corrective care.

It is significant that much emphasis is placed upon history taking, upon the interpretation of findings, and upon the reports to those examined. There can be no doubt that these matters are scarcely less important than the excellence of the physical examination itself.

The authors have had the assistance of a number of distinguished collaborators who have written sections of the work. Each chapter is followed by a well-selected bibliography. Individual opinions may differ somewhat as to the relative importance of certain procedures in examining technic and as to the weight to be attached to one or another finding, but the fact remains that there is now at hand for the first time a comprehensive manual for the stimulation and guidance of physicians now summoned from all sides to render one of the most useful services which medicine can offer to a needy world.—*Wade Wright.*

Hygiene and Sanitation. The Essentials of Modern Health Care. By *Jesse Feiring Williams*, M.D., Professor of Physical Education, Teachers College, Columbia University. Cloth. Pp. 344 with illustrations, bibliography, and index. Philadelphia and London: W. B. Saunders Co., 1927.

The object of this book, according to the author's preface, is to present the fundamentals of personal hygiene and sanitation in a manner primarily designed to serve the needs of the teacher and the more elementary student.

A general survey of the problem of the care of health in modern times (Chapter I) serves to define the problem which is then discussed in more detail with reference to the adult in the following chapter. Here one finds a definition of health and a presentation of the six essentials for personal health: physical activity, food, air, rest and sleep, care of the body, and straight thinking.

The care of the expectant mother is the subject of Chapter III. Here one finds a very satisfactory presentation of the problems connected with the life,

habits, and activity of the mother-to-be, and a very brief discussion of antepartum care.

The next three chapters are devoted to the care of babies and young children, of older children, and lastly of the aged and infirm. In these three chapters is presented a very satisfactory discussion of the subject matter. There is no doubt, however, that along certain technical lines the book discloses misstatements. For example, in Chapter V we are told rather dogmatically that mineral dusts produce their harm through the sharp cutting action of the particles. Earlier in this same chapter we are told that "Buildings ventilated by open windows present little or no difficulty because the outdoor humidity usually controls, and no essential value is achieved by attempting to secure indoor conditions different from outdoor."

Health care in disease (Chapter VII) is an adequate and excellent presentation of the subject; this chapter presents in detail a large portion of the Report of the American Public Health Association Committee on Standard Regulations for the Control of Communicable Disease.

The effect of the home and factory environment are discussed in two chapters, the volume finally closing with a chapter on health care on an international basis.

It is obvious that a discussion of these important subjects in a limited scope of approximately 320 small pages must be very general. The author touches the chief points in a very thorough fashion, but of necessity the details of many of the topics are rather sparse. To the experienced and critical reader, certain minor defects of facts are evident, but in general it may be said that the book is sound and should be highly instructive to the elementary student.—*Leonard Greenburg.*

BOOKS RECEIVED

Books received are acknowledged in this column, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers and as space permits.

THE MEDICAL DEPARTMENT OF THE ARMY. ITS HISTORY, ACTIVITIES AND ORGANIZATION. By *James A. Tobey*, Major, Sanitary Corps (Reserve), U. S. A. Institute for Government Research, Service Monographs of the United States Government, No. 45. Cloth. Pp. xii, 161 with appendixes and index. Baltimore: The Johns Hopkins Press, 1927.

CITY HEALTH ADMINISTRATION. By *Carl E. McCombs*, M.D., National Institute of Public Administration and New York Bureau of Municipal Research. Cloth. Pp. x, 524 with bibliography and index. New York: The Macmillan Co., 1927.

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